

G. R. S. IX-5]

Previous references.

for 36-29618

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File No. 36-24

Serial Nos.

Later references.

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GENERAL AND REVENUE SECRETARIAT.

Serial Nos.

One and

Part B for

Sept 20

SUBJECT.

Report on work done by M. O. Sampatadhyam
by Director

For.

(1)

The Director, Dept of Revenue

No. 383 of 25.8.20

For a copy of

Director's report giving account description
of the financial observations made by
during the period of his deputation to
N. India

On
4/10

~~12~~

Serial
No.
7.

From the Director, Dept of Geology
No 383 & 258-20.

Forwards a copy of Part II of Mr.
Samrat Dzungar's report giving details of descriptions of
the geological observations made by him during the period
of his deputation to Northern India.

Submitted for kind perusal

MS
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by

Chief Secy

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69/20

For perusal

1st ~~2nd~~ member

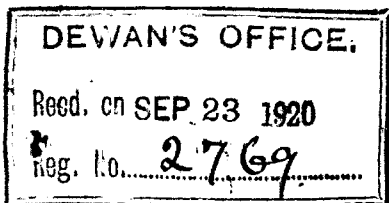
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CHIEF SECRETARIAT.

IV

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No. 383

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Section. Col 36-11-1

File No:

Serial No:

B. JAYA RAM, ESQUIRE, F.G.S.,

Director, Mysore Geological Department.

Dated, Bangalore, 25-8-1920.

From

To

C. S. Balasundaram Iyer, Esquire, B.A.,
Chief Secretary to the Government of His
Highness the Maharaja of Mysore.

Sir,

In continuation of my letter No.2407, dated 20th/
22nd May 1920, forwarding a copy of a letter, dated 7th
May 1920, from Mr. P. Sampat Iyengar, Deputy Director, with
a copy of Part I of his report on the work done by him
during the period of his deputation to Northern India
from January to April 1920, I have the honour to forward
herewith a copy of part II of his report giving detailed
descriptions of the geological observations made by him
during the period of his deputation.

I have the honour to be,

Sir,

Your most obedient servant,

B. Jaya Ram

Director,

Mysore Geological Department.

C.N.

CHIEF SECRETARIAT.
IV
MINOR Depts.
26 AUG 1920

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Deputation Report.

Part II - Descriptive.

*

As has been noticed in the reports of the Geological Survey of India, the schistose rocks of Chitaldrug and Shimoga Districts continue in a N.N.W direction into Bellary and Dharwar. There are a series of low continuous chain of smooth looking schist hills after passing Harihar on either side of the Railway line. Between Hubli and Dharwar the Railway cuttings expose gritty schists, resembling the felspathic and micaceous gruts of the Champion gneiss series, and the Haematite Quartzites. It is quite likely that this run of schist is a continuation of that of the Shikarpur area. Beyond Dharwar crushed biotite gneissic outcrops are met with in the interesting forest clad country bordering N. Kanara.

The Deccan Trap flow which occupies such an extensive area in India makes its appearance just before reaching Belgaum, obscuring all the underlying formations and can be followed up without a break all along the Railway line to Bombay and Nagpur. The trap flow appears to be thick in the neighbourhood of Bhorghat. It presents a perfectly horizontal appearance and rarely has any inclination. The several terraces and ledges noticed in cliff sections probably represent different flows of varying texture. Spheroidal weathering is quite common. Very good instances of columnar and rectangular jointing can be seen before and after Kalyan Station. Long slender columns of basalt stand out prominently as sentinels on the tops of hill ridges in consequence of the breaking off of masses of basalt through such joints. Amygdular cavities filled with white zeolites and greenish glauconite are a marked feature of the basalts, especially of the coarse textured flows. The usual agates, Jaspers and quartz crystals are frequently found throughout the area. It

is

* Records G.S.I. Vol. XXI Pt.2 and Vol. XXXIV, Pt.2

It is very interesting to follow the different textures and structures presented by the Traps in the much wooded broken up country approaches to the Ghats, but when once the tops of the Ghats are reached the outlook becomes dreary and monotonous for the Railway then passes for miles through level stretches of Trappean country covered with a thin layer of rock soil which nearly supports the growth of vegetation.

Central Provinces.

In the excellent guide book 'Nagpur and its Environs' supplied to the members that attended the Indian Science Congress, 1920, Dr. L.L. Fermor has given a succinct account of the geological formations met with in the district of Nagpur. With very few additions the same ~~good~~ descriptions hold good to the rest of the Central Provinces.

The Geological formations observed by me in the rapid tour in Central Provinces are the following in ascending order:-

<u>Formation.</u>	<u>Rock description.</u>	<u>Area.</u>
(1) Archaen Rocks:-	Metamorphic & Crystalline Schists & Gneisses.	In the neighbourhood of Bheemalgundi, Ramtek, Balaghat, Sihora and Jabulpur.
(2) Vindhyan:-	Limestones, Clays & Sandstones.	At Katni & in the Kaimur range.
(3) Gondwanas:- Kamthi group. Jubbulpore "	Grits, sandstones & Shales. Sandstone & Clays.	Near Borgaon. At Jubbulpore.
(4) Lameta (Ingra trappean) }	Limestones &c.	Bheemalgundi & Jubbulpore.
(5) Deccan Trap.	Basalt.	Chiefly near Nagpur, Bheemalgundi, Chhindwara & Jubbulpore.
Intertrappean.		Near Nagpur & Jubbulpore.
(6) Laterite	----- Bauxite.	At Sihora. At Katni.

<u>Formation.</u>	<u>Rock description.</u>	<u>Area.</u>
(7) Recent		
Older alluvium		Nagpur and Chhindwara Districts, & Nheraghat Nerbudda.
Newer alluvium.		-do-

The Archaen rocks.

From a study of the disposition of the rock formations in Central Provinces it can be inferred that the very much later formed Deccan Trap extended beyond its present limits and probably formed a continuous sheet over a large portion of the area now represented by the Archaen complex. The denudation effected by the Kanhan, Wainganga and Nerbudda rivers with their tributary streams has apparently been the cause of the exposure of the underlying older formations. This feature can well be observed in the neighbourhood of Bheemalgundi and to the west of the Pench River where several long irregular spurs of the Trappean rocks enclose valleys exposing the metamorphic schists and gneisses (Vide Geological Sketch Map Pl.43. - Mem. G.S.I. Vol.XXXVII).

Bheemalgundi.

Of all the Archaen areas visited by me in this tour nothing was petrologically more interesting than Bheemalgundi. I was able to observe here thin stringers of dark hornblende schist which in a few places had developed at contact with either quartz vein or pegmatite, secondary augites, like the hornblende schists of the Javanhalli formation in Mysore. They occurred as caught up patches in the typical biotite gneisses, which constituting the main mass of the Archaen in Central Provinces petrologically resembled the Peninsular gneissic complex of Mysore. Besides these I noticed in the highly folded zones, large masses of biotite, silliminite gneisses ("Tabloid gneisses"), and quartz Pyroxene gneisses,

calciophyres and crystalline limestones which Dr. Fermor considered at one time to be not simple metamorphosed sediments but chemical alteration products of preexisting rocks, containing an abundance of lime (& Magnesia) silicates, through the introduction from without of carbon dioxide^{*} Now he is inclined to regard them as remnants of metamorphosed sediments formed at contact with the intrusive biotite gneiss of the region and divisible into two distinct series of rocks - the calc and the dolomitic series; The former to consist of calc granulites and the crystalline limestones and marbles with the associated Manganese Ores characterized by the presence of calcite; and the latter to consist of Diopsidites and the white yellowish/dolomitic limestones and marbles having dolomite as the essential constituents. The first series therefore takes in most of what has been described previously as Quartz pyroxene gneisses, Calciophyres and the first two classes of crystalline limestones mentioned on page 167 Records Geol. S. I. Vol. XXXIII Pt. 3, while the second series includes some of the quartz pyroxene gneisses having diopsides and chondrodites and the serpentinous limestones and Cipollinos. As regards their origin he has practically reversed the views formerly held and is now of opinion that the calc granulites and the diopsidites represent the farther metamorphosed stage of the crystalline limestones and marbles.

The formation of such minerals like diopside, spinel and garnet and piemontite and sphene is attributed to the interaction between the crystalline limestones (metamorphosed calcareous and Manganiferous sediments) with the intrusive gneiss having biotite and sphene. The occurrence of chondrodite is regarded as the effect of pneumatolysis.

* Rec. G.S. I Vol. XXXIII Pt. 3. Page 168

The finding of muscovite with rutile grains and prisms in some sections of the gneiss at contact is thought of as due to the alteration of the biotite. When some portions or layers of the calc granulites show a large preponderance of microcline they are regarded as having excess portion of the intrusive gneiss and when they show labradorite then they are taken to represent the presence of crystalline limestones (metamorphosed sediments) in excess.

Dr. Fermor in his Notes on the Petrology and Manganese Ore deposits of Sausar Tabsil, Chhindwara District, pp.175-207 has clearly and vividly described the typical rocks, constituting the metamorphic and crystalline series. The same Macro & Micro descriptions apply to the rocks that I have collected in the neighbourhood of Bheemalgundi. My interpretation of their origin is more in harmony with what is mentioned therein and completely differs from the present changed views of Dr. Fermor. From a comparative study of the rocks of this area with those found in Mysore State, such as the Hornblende Schists having secondary augite (Tarurites) and the Javanhalli limestones, and from an examination of the evidences afforded by them in the field I am of opinion that the Quartz Pyroxene Gneisses and Calciphyres (now reckoned as Calc granulites and diopsidites), represent the highly metamorphosed phases of lenticular dark hornblende schist patches in the intrusive biotite gneiss of the region. These have to be regarded as Dharwars in age.

The typical Quartz Pyroxene Gneiss D₇₂ from the Utikata range of hills - a descriptive extract of which is given below - in no way differs from the Tarurite rock met with in Mysore.

* Rec. G.S.I. Vol.XXXIII, Pt.3,

The rock is rather fine-grained, somewhat granular in appearance, of a general greenish-grey colour, and is exceedingly tough and compact. The greenish-grey colour is due to dark green grains of pyroxene and yellow-green grains of epidote sprinkled in a whitish groundmass of quartz and felspar of which the grains are roughly the same size as those of the pyroxene and epidote. M.- The rock has a pan-allotriomorphic structure, in which none of the prominent minerals are markedly idiomorphic. The minerals seen are :- plagioclase sometimes zoned, and then consisting of labradorite of medium composition inside with an outer shell of acid labradorite; microcline fresh and small in amount; pyroxene, varying from pale to quite strong green in colour (a single individual being often irregular as regards the depth of the green), practically non-pleochroic, and having an extinction angle of 35° - 40° measured on those sections nearest the clino-pine acid; hornblende, both intergrown with the pyroxene and bordering it, and showing the following pleochroism scheme :-

- a = Yellow-green,
- b = emerald-green,
- c = blue-green;

quartz, fairly abundant, and usually not much strained; epidote which may be secondary, as it seems to have grown around a nucleus, of some other mineral such as sphene, itself possibly of secondary origin; calcite, just a little, no doubt secondary; sphene, abundant, more or less idiomorphic (wedge-shaped) and as a rule nearly colourless, but sometimes with cinnamon-brown patches in the centre; zircon, and iron-ore (ilmenite ?) both in fair amount.

I visited the Utikata ridge and found numerous thin quartz reefs and pegmatite veins intimately associated with these quartz Pyroxene gneisses (calc granulite).

Similarly I saw several white and pink quartz reefs and
thin

thin pegmatitic and granitic veins in the midst of the calc granulites D₄₆ and the diopsidites D₄₄ & D₄₅ on hill to the north of the East Devi Manganese ridge. In all probability as in Mysore these quartz veins and pegmatites have intruded the Hornblende schist and have given rise to the secondary pale green augites (diopsides) and other constituent minerals. Through further change some portions of the rocks have been converted into calcite bearing Calciphyres, in the manner suggested on pp.168-171 Rec. G.S.I. Vol.XXXIII Pt.3 by the descending aqueous solutions having C O₂.

It is true that in this field pink and white crystalline limestones and marbles are met with in close proximity to the rocks described above, but they always occur as distinct runs folded in more or less conformably with the latter but never forming part of them. In other words, as far as I have seen, in the same run gradation rocks displaying the passage of one into the other do not occur, and it has been always easy to map them as separate entities. The mere coincidence of the finding of a few minerals like diopside and Sphene in the two sets of rocks should not be taken as indicative of a genetic relationship, for it is a well known fact that rocks having different origins may also derive the same minerals through metamorphism. If the diopsides occurring in the limestones and in the Quartz Pyroxene Gneisses and calciphyres be chemically examined, I believe there will be marked difference. Moreover the crystalline limestones and marbles contain minerals like piemontite, chondrodite and phlogopite which are absent in the calciphyres series; and the Manganese ores too have been known to be associated only with the former and never with the latter.

I agree with Dr. Fermor in so far considering the crystalline limestones and marbles (Calcite, dolomitic and serpentinous) as the derivatives from the metamorphism of calcareous

(magnesium bearing) Sediments, but I cannot subscribe to his views to regard them as in any way genetically connected with Quartz Pyroxene Gneisses and calciphyres which he is now inclined to classify as calc granulites and diopsidites. The limestones and marbles occurring in the Pench River at Gohra and the marble rocks at the famous Bera Ghat Nerbudda river have had probably a similar origin.

"The limestone rocks are never more than a mile or so long and often much less. They are very abundant and though they often contain a profusion of accessory minerals arranged more or less in bands would probably make handsome marbles should a demand for them arise". We have nothing in Mysore to compare with these splendid limestones and marbles, for our limestones have originated altogether in a different manner either by the alteration of rocks containing secondary augites (the Javanhalli limestone), or through the development of calcite in calciferous chlorite schists by the invasion of thin quartz reefs, or by the alteration of feldspars and other mineral constituents of the Champion Gneiss series through aqueous solutions holding CO_2 . Such differences in origin probably account for the not finding of minerals like piemontite, Chondrodite & phlogopite in the Mysore limestones.

It is ^a fact worthy of record that in this region a curious white barked tree 'Sterculia Urans', which may be called 'Skeleton tree' on account of its numerous sinuous leafless branches rears itself above the surrounding dense foliage, only where the limestone rocks abound. It thus very often unmistakably affords a clue to the run of these limestones. The horizon of the limestoney Lameta rocks below the Deccan Trap is also marked by the presence of this tree.

Between

Between Seoni and Nainpur along the Railway line, I have noticed this tree growing even on the Deccan Trap and hence it cannot be said to be solely confined to the limestone areas.

The rocks near Bheemalgundi occur in bands and die out in a lenticular fashion. The outcrops on the field display terrific twists and sigmoid flexures. Dr. Fermor was kind enough to show me his field maps and it is evident therefrom that the Archaen rocks of the region has been subjected to intense folding often resulting in anticlinoriums and Synclinoriums. Faulting of rocks apparently are quite numerous. While constructing a geological section across an anticlinorium with the noted dips from the East Devi ridge to Ghadela ? it was observed that the limestone and marble bands (including the dolomitic & serpentinous limestones) appeared more or less in the highly folded axial zones. It is quite possible within the bounds of probability that this accounts for the almost complete conversion of the calcareous sediments into crystalline limestones and coarse marbles through intense pressure pressure and heat developed at the axial bends. A few intrusive Quartz reefs also appeared at the folds.

A band of manganiferous rock (D₄₉ & D₅₀) intercalated with the crystalline limestone is noticeable on the northern slope of the high East Devi ridge; and it contains spessartite, rhodonite, rhodochrosite and phosphoric Manganese Ores. Also another new green blue vitreous lustered granular mineral (D₅₁), probably phosphate, is present in the rock and this requires investigation. "There is much Quartz banding in the ore and manganese silicate rocks; and in places this quartz contains manganese garnets upto half an inch in diameter".

The occurrence is considered to be the probable continuation of the Alesur Manganese Ore band which is said to show a gradual passage from a white crystalline limestone to

Spessartite

Spessartite Quartz rock or Gondite. It is quite probable that in this disturbed region other metamorphic schists (Manganiferous) may have got folded along with the crystalline limestones, and the subsequent intrusion of Quartz Reefs ^{may} have been responsible for the development of Manganese bearing garnets and silicates. The presence of Rhodonite also in the crystalline limestones is very significant and suggestive.

The limestone adjoining the ore band is black D₄₇ owing to the deposition of Manganese Oxide along the cleavage and twinning planes of the calcite. This is subsequent to the formation of the Manganese minerals.

In the Balaghat area, Central Provinces, to be described in detail later on, there are phyllites with subordinate slates & Mica schists forming part of the Chilpi Ghat Series. They also have manganese ore layers interbanded with them and with the vitreous quartzites. Studied as a whole the Chilpi Ghat Series of rocks present a sedimentary aspect and are decidedly older in age and the adjoining intrusive biotite gneiss of Peepertola Ghat.

At one time on account of the not finding of Manganese silicates, the Chilpi Ghat Ore deposits were reckoned as distinct types to those occurring in the metamorphic and crystalline complex in other parts of ^{the} Central Provinces. An eruptive origin was suggested to the latter (constituting a part of the Gondite Series) on the analogy of the Kodurites in the Vizagapatam District. But subsequently on the finding of the spessartite Quartz rock in the Manganese Ore layers at Ukua, ~~me~~ more or less in the same horizon as the Balaghat deposit at the base of the Chilpi s, it has been thought desirable by Dr. Fermor to revise his original views of the two types of rocks - the Chilpi and the Gondite Series - and to derive both

from the metamorphism of Manganiferous sediments. In the Memoir Vol. XXXVII page 287 - 293, he has given an elaborate theoretical account as to how the ore bodies can derive their manganese silicates Spessartite, Rhodonite &c. from the interaction of the manganese oxides with any interstratified or admixed silt[&] with the 'country' or wall rock. The originally entertained intrusive view for a portion of the Gondite Series was thus abandoned. Further to support the metamorphic sedimentary view the presence of the 'schistose conglomeratic sericitic grit' at Balaghat and 'the Schistose micaceous gneiss often containing pebbles of quartz, granites & gneiss' at Ukua were reckoned as sedimentary conglomerates; A correlation was instituted between the Sita-saongi silvery mica schists and phyllites of Balaghat & Ukua on the similarity of the minerals, found in them such as idiomorphic^x lavender coloured tourmaline, ottrelite, magnetite or ilmenite and rutil^{*}.

In my hurried trip through the Central Provinces, I visited a few of the important manganese localities of Kachi Dana, East Devi, Goghra, Kandri & Balaghat. From a study of the associated rocks I fully entertain the view that metamorphosed manganiferous sediments have mainly contributed to the formation of the Primary Manganese Ore bodies in Central Provinces, but that in a few places like Kachi Dana and East Devi ridge the intrusive quartz reefs (or alaskites) have played also an important part in the development of Manganese Ores by giving rise at contact to such minerals like spessartite & Rhodonite. It is quite possible that the type rock gondite composed of quartz and spessartite whenever found has been derived in this manner.

* Mem. G. S. I Vol. XXXVII p.312 & 313.

It has been admitted that there are "masses of pegmatite or other acid igneous rocks concerning the intrusive relation of which with regard to the manganese ore bodies there is often unequivocal evidence". In piercing the manganese ore bodies they (these intrusive acid rocks) took the opportunity to absorb portions of the rocks through ^{which} they passed with the consequence that when they solidified the absorbed mangani-ferous material gave rise to minerals not usually found in such intrusives. The formation of spessartite Quartz rock (typical Gondite) at Kandri, Kachi Dana and other localities should, I think, be attributed on the analogy of the garnet quartz rock of the Kodurites (to be described later on), not to the metamorphism of impure mangani-ferous sediments but to intrusion of quartz reefs in mangani-ferous rocks resulting in the formation at contact of manganese silicates which have yielded the manganese ores. If we take the Alaskite - a quartz felspar rock - as the intrusive it will account for the members of the Gondite series. At Balaghat the "Schistose Conglomeratic sericitic grit" relied upon by Dr. Fermor as sedimentary for bring^{ing} about the correlation of the Chilpi manganese ore bodies and the Gondites in the metamorphic and crystalline complex proves to be only an autoclastic conglomerate at the intrusive margin of the adjacent micaceous gneiss. One can easily see at the 12th mile at the Peepertola Ghat road how this micaceous gneiss has formed through intense folding and pressure an autoclastic conglomeratic structure even in the main mass of the gneiss. Dr. Fermor also now regards the Balaghat and the Ukua grits and conglomerates as autoclastic in character and not sedimentary.

It is a curious fact that lavender coloured tourmalines characteristic of igneous and metamorphic rocks are found both in the Quartz siliceous schists of Central Provinces and the intrusive Quartzites ? (Delhi Series) of the Aravallis at Ajmeer.

In Mysore (kudramukh area) at the junction of Quartzose phases of the gneisses with amphibolites, silvery white mica schists having rutiles have been noticed to occur and it is quite possible that the titaniferous minerals in the Sita-Saongi rock may also be due to similar contact action. At any rate no definite case has been made out by Dr. Fermor to discard an igneous theory originally contemplated for a portion of the Gondite rock occurrences.

The general look and nature of the schistose rocks, especially the phyllites, the haematite and mangiferous ore bodies, jaspery haematite quartzites in the Nagpur Balaghat and in the Jubbulpore areas, being quite different to the Dharwar Schists in Mysore, it is, I think, incorrect to correlate the two, and assign more or less the same age. The former clearly have a sedimentary aspect and present a less metamorphosed aspect than the Dharwars. Moreover it is rarely or never that we find banded Hornblende Schists and haematite quartzite to the same extent as in Mysore. On the other hand, considerable bodies of bedded soft haematitic schists, manganese ore bodies and Jaspery haematitic Quartzites are found as replacement of the phyllites and Quartzites. Further, the limestones and marbles of the Central Provinces are highly crystalline and are quite unlike the limestones in Mysore. Instead of treating them as metamorphosed Dharwars I put forward the suggestion that they may be regarded as post Dharwars in age, probably Cuddappa's, since they show good many resemblances to that formation, especially in having the red Jaspery H.Q. Their stratigraphical position in Central Provinces with reference to the gneisses cannot be urged as an insurmountable barrier for the acceptance of this suggestion since I have noticed near Tirupati intrusive relationships between the typical Cuddappahs and the gneisses

and I dare say if the main mass of the Cuddappas are properly examined they will show many such intrusive contacts.

Before I pass on to the description of the latest members of the Archaens - the intrusive biotite gneiss &c. I wish to mention the silicification of rocks that has taken place on an extensive scale in this area. The dolomitic and serpentine limestones on the top of the conical hill situated at the S.E. corner of Ghadela village, Sausar Tahsil, have been converted into brown cherty masses D_{41} , to a depth of 30 to 40 feet. Similarly other rocks too are affected. I agree with Dr. Fermor in regarding the silica that might have been introduced in solution from the once extensive overlying Deccan Trap as being the probable agent which has more or less completely replaced the adjacent rocks.

As is the case over so large a part of Peninsular India the principal Archaen rock of the Central Provinces is the the gneissic complex consisting of successive intrusions of granitic masses. The type rock which occurs widely is the biotite gneiss. The very many variations observed are due to the degree of foliation, the coarseness or fineness of grain, to the presence or absence of porphyritic crystals of feldspar, and to the amount and nature of mica in the rock. Sometimes the gneiss is hard and bouldery, but more often schistose. In a few places, as at Peepertola, it has developed 'Augen' structures and an autoclastic Conglomeratic appearance as well. Numerous large aplite or pegmatite dykes often showing graphic intergrowth of quartz and feldspar and rarely of tourmaline and quartz D are found traversing the gneissic complex in every direction. The usual minerals quartz, microcline, clouded plagioclase, biotite, apatite and zircon constitute the typical biotite gneiss which appears to

be intrusive into the schists - the Dharwars and the Chilpi's. Hornblendic biotite gneiss is not uncommon and it is stated that it probably has affinities with the quartz pyroxene gneiss on account of the similarity in mineral contents and in sp.gr.* Within the limits of Ghadela village $\frac{1}{2}$ mile to the N.E. of the conical dolomitic hill referred to so often, I noticed a run of this hornblendic gneiss, and not far from it there were a few small patches of H.S. and Tazurite. This local occurrence of the mineral hornblende in the otherwise purely biotitic gneiss of the area seems to be the result of assimilation of hornblende schist. The development of such hornblendic gneisses in areas where gneissic granites have invaded the hornblende schists are not uncommon in Mysore. (Vide M.G.D. Bulletin No.9 pp.16).

In contact and in shear zones, much silliminite in addition to the sericite and biotite is developed in the gneiss. The former mineral on weathered surface of the rock usually stands out as bold outstanding lenses or patches. On account of this Dr. Fermor has styled it 'Tabloid' or 'Spindle' shaped gneiss. Bheemalgundi area ^{which} has been subjected to severe tectonic disturbances affords good illustrations of such silliminite gneisses; so also the Pench River at Goghra.

Ramtek.

In company with the other members of the Indian Science Congress that started out from Nagpur on an excursion, I paid a hurried visit to the Kandri Manganese Mine in the neighbourhood of Ramtek. Our stay at the mine being of short duration it was not possible for me to study the manganese occurrence carefully. Any how I noticed the Gondite rock - Quartz spessartite in intimate relationship with what appears to be a crushed phase of biotite gneiss. In places the latter rock

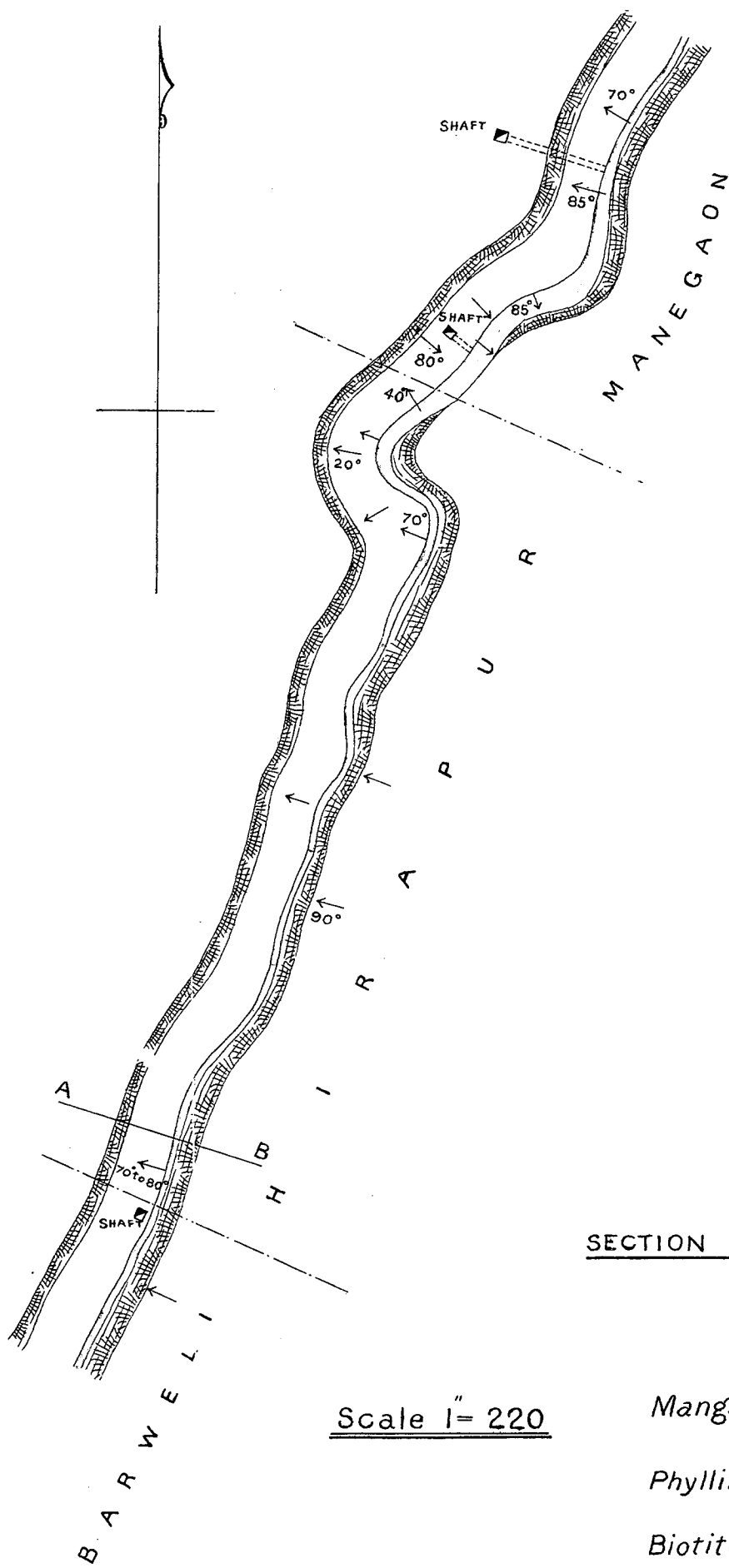
* Rec. G.S.I. Vol. XXXIII Pt.3. pp.181.

resembles very fine grit or sandstone D_1 & D_3 and Manganese oxides in solution have been formed along the cracks and joints. Manganese dendrites are quite common. Mica Schists with subsidiary bands of gneiss are to be seen in the valley between the North and South hillocks. The origin of the Manganese Ore band at Kandri though not clear is, I think, akin to the bedded deposit of Balaghat and is probably a metamorphosed Manganiferous sediment. There is no doubt that the rocks of the region are highly folded and disturbed.

My next visit was to the magnificent exposure of the crystalline limestones at Goghra in the Pench River about 2 miles N.E. of Parsioni. I have nothing much to add to the splendid description given of the outcrop by Dr. Fermor. The Manganese Ores do not occur in distinct and separate layers, but show up here and there in the crush zones of the ~~crystalline~~ crystalline limestones often closely associated with piemontite, which occurs in silky red patches and streaks. It looks as if the intrusion of thin quartz veins or aplites coupled with crushing have led to the formation and segregation of these minerals. Close by is a distinct run the silliminite 'Tabloid' gneiss which has tourmaline as well.

Balaghat.

This, the largest producing manganese ore deposit in India occupies a S.S.W. ridge jutting out into the plains to within 2 miles of the town of Balaghat. It is situated within the limits of the 3 villages of Bharweli, Hirapur and Manegaon. A graphic description of the occurrence with photographs and sketches is given in the Manganese Memoir G.S.I. Vol. XXXVII pages 714-726. There appears to be little doubt that the ore body, which now occurs interbanded with vitreous ^{quartzites} and phyllites (with subordinate ottrelife Mica Schists), first started
existence



SECTION ON A.B.

Scale 1" = 220'

- Manganese ore ----- 
- Phyllite ----- 
- Biotite Gneiss ----- 

existence as a manganiferous sediment in the midst of arenaceous and argillaceous materials.

The bed of manganese occurring here has a varying inclination of 45° to 80° West and is almost vertical in Hirapur limits. Close to the village boundary between Hirapur and Manegaon there apparently is a small fold, for the bed not only has a shallow dip but also shows a change in the direction of dip from West to East. But this disturbance is only local for the original dip angle and direction is again resumed. The following sketch though not intended to represent the actual outcrop is meant to illustrate the thickness curves, and dips of the manganese ore body as seen in the deep excavations at Manegaon and Hirapur. At the former place the depth of excavation is about 70 feet and at the latter about 150 feet. The average width of excavation is about 125 ft.

There are evidences to infer that the vitreous quartzite, which often presents a soft and friable sandstone aspect D₇₄ and the micaceous finely laminated phyllite D₇₇, have been replaced by manganese oxides from the periphery inwards. As observed by Dr. Fermor portions of the unaltered friable quartzites which on breaking crumble into a red powder (like brick dust) occur also as rounded nodules enclosed in the manganese ore D₇₃. Sometimes the quartzites are black and hard like flint. The Jaspersy H.Q. boulders are met with at the northern end of the deposit in Manegaon limits.

The schistose conglomeratic sericitic grit described as forming the eastern margin of the Balaghat schist patch can be traced to have consanguinity to the intrusive biotite gneiss of Peepertola Ghat. It is autoclastic in nature and Dr. Fermor too now is of the same opinion. It looks as if the granite has intruded and cut off a portion of the phyllites and the associated manganese ore body to the North.

The Balaghat Schist patch is said to be of Chilpi Ghat

Series and it has been correlated by previous observers with the Dharwars in Mysore. In another place I have my reasons for differing from entertaining such a view. I think they are probably Cuddappas in age.

I give below some statistics I was able to obtain from the foreman of the mine. Nearly 2000 coolies work here almost every day and the daily output of manganese ore is about 200 tons. The coolies work 8 to 10 hours per day and are paid 5 annas & 3 annas each man and women respectively.

The work of getting the manganese ore (Braunite & psilomelane) is let out on contract; and the contractor is paid either Rupee one and two annas or nine annas according as he supplies 22 to 25 cub.ft. or $12\frac{1}{2}$ cub.ft. to fill in the larger or smaller trucks. In this case the contractor has to use his own explosives. If the Company supplies the explosives then he is paid ten annas or twelve annas per ton of ore proportionate to the lead. There appears to be no trouble in securing labour in these parts.

There are 3 gravity inclines at work - the descending loaded trucks hauling up the empties. The ore is all stacked in the plain below to the west of the ridge to which place there is a Railway line branching from the main Gondia Jubbulpore line a mile off Balaghat Railway Station.

Sihora.

A very good illustration of Manganese & haematite or limonite ores ('Lateritoid') formed by the partial replacement of the phyllites & Jaspideous Haematite Schists can be seen on the Silondi Mansakra ridge not far from the town of Sihora, Jubbulpore District. The deposit has evidently been

* For description see P.P.806 & 822, Mem.G.S.I.Vol.XXXVII.

worked for pyrolusite and psilomelane for there are several disused pits not more than 6 to 10 ft. deep which show the ore in streaks in what appears to be the brecciated lateritic mass. On careful examination of the rock mass I saw residual portions of the phyllite which had evidently been replaced by iron and manganese oxides in aqueous solution. In this respect it resembles the lateritoid masses of iron ore on the Bababudans. There appears to be a further segregation and development of limonite and pyrosulite in cracks and fissures in the rocks of this ridge, for radiating and botryoidal forms D_{110} of these minerals are found in alternating layers. The limonite is of a golden yellow color in places and resembles the mineral X/756 noticed in the iron ^{ore} deposits at Kemmangundi on the Bababudans and which has the Chemical Analyses.

FeO,	Fe ₂ O ₃ .	Al ₂ O ₃	Combined water,	SiO ₂ .	Moisture at 100° C
Nil.	74.06	12.01	15.11	0.74,	2.26.

The occurrence is not unlike some of the Manganese deposits of the Dod Guni area in Mysore.

Just on the northern end of the town of Sihora, within 100 yards west of the road to Katni, there are deep excavations for road metal in Jasper H.Q. and phyllites. The latter through slight crushing has assumed a nodular appearance and some blocks in the quarry face have actually developed a ~~pisolitic~~ pisolitic structure D_{113} the effect of which is heightened through coloration D_{114} . This is not unlike the bauxite formation at Katni to be described later on.

The ridge that starts from near the Dak Bungalow at Sihora is composed of soft muddy shales (phyllites ?) of different tints pinkish, gray &c., and of dark micaceous haematite schists having a satiny sheen. When Jasper layers are developed in the latter, the haematite schists slightly stick out and appear prominent in the middle of the other schist layers.

layers. The Jasper H.Q. ring like schist slates under the hammer and break into sharply defined angular or rectangular pieces. "The rock is often extraordinarily contorted and when this is the case bands of Jasper or haematite are frequently seen to thin or thicken in a lenticular fashion or even pinch out entirely".

As far as I have noticed, these haematite quartzites do not outcrop boldly on hill ridges as in Mysore. The dark haematite schists are further spotted and have also in places small well developed Octahedrons of magnetite.

I am of opinion that these muddy shales (Phyllites) and Jaspery H.Q. are not probably Dharwars for they have a distinctly sedimentary facies and have not undergone the same amount of metamorphism as the Dharwars to be stylized crystalline schists. They look to me as ferruginous and manganiferous clay sediments compacted and slightly metamorphosed. The nearest approach that we have in Mysore are the clayey schists at Manighatta, Kolar District.

Marble rocks, Nerbudda Gorge.

Any one who visits the famous Bhera Ghat is sure to be impressed with the majesty and grandeur of the Gorge carved out in the 'Marble rocks' by the Nerbudda river.

Words fail to convey its magnificiance and nobody who goes there should miss the boat trip through the narrow Gorges and defiles where the different tinted saccharoidal whitish and bluish marbles are exposed almost perpendicularly in cliff sections to heights of 120 to 150 ft. on either banks which in places are not more than 20 yards apart. Taking advantage of the inaccessible height of the cliffs, the much dreaded bees apparently had their beehives in the Gorge, but now they have all been removed. A good many irregular ^{shaped} pot~~s~~.

potholes are in evidence and the guides who take the Visitors round, point to them as 'Elephant hoofs' and 'Horseeshoes'. The rocks at the gorge and at the water-fall close by afford an interesting study of the slicing off of huge blocks along bedding planes and joints by the action of the river. The marble rocks are highly jointed in two directions almost at right angles to the bedding planes, and the river water taking advantage of these divisional planes flows along them giving rise to Cataracts and waterfalls. To a considerable distance at the water fall the river has a deep course along the bedding planes. The Sinuosities in the gorges, the peculiar shaped huge masses of marble constituting islands in the middle of the river, and the perpendicular cliffs are nothing but the effects of irregular erosion of the river bed.

No better or pure white Saccharoidal marble D₉₇ can be found elsewhere in India than in the vicinity of the gorge, and it is possible to raise a very large quantity. Other tints too, such as blue D₉₆, Rose red D₉₅ and yellow D₉₄, there are, but their quantity is insignificant.

In the midst of the marbles, along the strike, occurs irregular thin lenses of beautifully soft and non-gritty potstone apparently derived from the alternation of tremolite Schist D₈₉ not more than 6" to 2 ft. wide. The potstone or steatite quarried from here as 1st quality is of a pale blue colour D₉₁. It is however not uniformly so and shades off into white, buff D₉₃ or yellow tints D₉₂. Chlorite Schist D₉₀ is also found in places in intimate association with the potstone.

The method adopted in quarrying the potstone is very primitive and crude. Irregular burrowings confined to the potstone outcrops alone are made here and there along the lie to a depth of a few feet and small pieces of potstone removed are then being hauled up to the surface in baskets with the aid

of the rope, or by being passed up from one to the other by women coolies. The men do the digging with crowbars and Mammoties.

A little to the north of the temple on the Beraghat rise and 200 yards from it is a large circular excavation about 70 ft. deep and 45 ft. or so in diameter for good potstone from altered Tremolite schists 1 to 2 feet wide appearing as thin parallel streaks in the marbles. There were 30 men and women working at the time of my visit, and I was told that each man was paid 6 annas and each woman 3 annas per day. There was no decent arrangement for persons to get down the pit. For part of the distance the persons slid down a rope attached to a tree at the top and then descended to the bottom of it by a rickety ladder 30 ft. long. It appears the potstone is removed to the Cement Works at Katni.

A good number of narrow dykes cut across the 'Marble rocks'. About 100 yards from the water fall there is narrow amphibolite dyke D_{88A} clearly crossing the bedding planes of the marbles and intercepting the thin thin quartz veins which appear to be fairly numerous in this locality. The dyke at contact has assumed a reddish colour. Again at the extreme end in the marble gorge up to which place the boats can ply, there is a dolerite dyke D₉₉ which runs right across the bedding planes of the marbles. The guides erroneously point to this dyke as black marble.

It is not possible to make out the origin or stratigraphical position of the marbles from a cursory inspection of the Beraghat locality, Geologists have classed them as 'Dharwars'. I may however point out that no such saccharoidal marbles are met with in the typical Dharwars of South India. Being not far from the metamorphic schist regions of Bheemal-gundi where large masses of crystalline limestones and marbles are in existence it is quite reasonable to infer that the famous 'Marble rocks' too have had an origin similar to those

in the Nagpur Balaghat area. Like the crystalline limestones at Goghra these marbles have also small irregularly distributed manganese patches at Gangai 4 miles south of Bhera Ghat.*

Summing up then I am inclined to regard the hornblende Schist in Central Provinces as the oldest igneous rock, Dharwarian in age. Next, after a long lapse of time, probably contemporaneous with the Cuddapa formation of Southern India, mechanically and chemically formed arenaceous, argillaceous manganiiferous and calcareous sediments appear to have been deposited over the denuded surface of the Dharwars. Subsequently the area was invaded by the gneiss of Central Provinces and the Jubbulpore syenites and the Bundelkhand granite which piecemealed the schists and metamorphosed them. In this manner the quartz pyroxene gneiss and calciphyres (now styled calc granulites and diopsidites) and the sandstones vitreous quartzites, phyllite and bedded manganese deposits and crystalline limestones and marbles (the Chilpi Ghat Series) probably originated and thrown together in small lenticular bands or patches in the midst of the intruding rocks. The later intrusive quartzes and pegmatites may have also aided in bringing about further metamorphic changes and in the development of new minerals like spessartite, Rhodonite, tourmaline and rutile. Owing to later tectonic disturbances all these Archaen rocks in Central Provinces have been subjected to intense pressure, shearing and folding which has resulted in the local formations of autoclastic conglomerates, anticlinoriums and Synclinoriums &c. and in the further metamorphism of the schists and gneisses. The occurrence of biotite silliminite ~~and~~ gneisses ('Tabloid gneiss') in shear zones, and the formation of coarse crystalline marbles with such minerals

* Bose Rec. G.S.I. Vol.XXI pp.72 & 87.

like peidmontite, Chondrodite and phlogopite appear to be due to these causes. Considerable faulting of rocks have ~~been~~ taken place in the area. At Kachi Dana Manganese Mine, pegmatite dykes have faulted the ore body and all. Several cases of faulting have been noted by Dr. Fermor in the gneisses and the overlying traps in the Bheemalgundi, Linga and other areas. Being subject to such severe strains numerous cracks must have been formed in the rocks which afforded easy passage for the free circulation of Aqueous solutions charged with manganese and iron contents. The secondary manganese and iron ores were thus brought into existence and they are by no means insignificant. A good portion of the Kandri and Balaghat Manganese deposits and the haematite schists of Sihora appears to be derived in this manner. The formation of reddish Jaspery rocks is some how or other intimately connected with such secondary ore deposition.

Such in brief seems to be the geological history of the metamorphic and crystalline schists and gneisses of the Central Provinces.

The Vindhya's.

The lower Vindhya's regarded by Mr. Mallet as a distinct formation but which has been considered by Mr. Vredenburg as constituting only a subsystem or series ^x are well developed in two distinct regions in Central India Viz., in Bundalkhand and in the Son Valley. At Katni I was able to observe the shale and limestone outcrops, the topmost members of the lower Vindhya's of the Son Valley. In all probability they represent the Rohtas group described by Medlicott and Blanford. The town of Katni is mostly on white shales that have been discolored red & yellow through ferruginous saturation. They

* Mem. G.S.I. Vol. VII p.28

x Rec. Vol. XXXIII Pt.4 p.258.

+ Medlicott & Blanford Geol. of India Pt.I page 80.

even pass into lateritic and bauxitic material. Underlying these conformably are two or three beds of very fine and even textured light greenish gray to salmon coloured limestones D₁₂₂ intercalated with shales. They all have a gentle dip to the North 5° to 20° and appear to be unconformably overlaid by the sandstones D₁₂₃ & D₁₂₄ of the Kaimur range which here form bold escapments having a direction for miles in unison with the strike of the strata.

The bedded limestones are quarried extensively and are burnt into lime in specially constructed kilns. Further they are made use of in the manufacture of Cement. The following is the analysis ^{of} a sample of Katni limestone :-

SiO ₂	Fe ₂ O ₃ Al ₂ O ₃	CaO	MgO.
4.18	1.22	52.10	0.74

The method adopted in obtaining the limestone is very simple. Large pits, rectangular or square, are sunk in the soil and shale to varying depths of 70 to 180 ft. until the underlying almost horizontal bed of limestone is reached. In the quarry visited the limestone D had a varying thickness of 4 to 8 ft. and this was being broken up into irregular chunks and pieces by jumpers and crowbars and transported to higher levels on headloads. Water was being pumped out by machinery. In some places where the ingress of water was excessive the pits were generally abandoned.

I also examined the sandstone of the Kaimur range (the lowest member of the Upper Vindhyan formation) in the neighbourhood of Katni. The sandstone is usually fine grained yellowish or grayish white, in color D₁₂₄. Pinkish layers too D₁₂₃ are not wanting. From some of the quarries beautiful large sized flagstones are being raised. Large massive blocks are also procurable, for in ~~the~~ places the sandstone beds are

homogeneous

homogenous, thick and also free from joints or fissures for long distances. They have a gentle dip Northwards. The railway between Sagauria Station and Lalitpur passes through sandstones several feet thick, which I take to be the upper Vindhyan (Bhandars) in age.

The sandstones are of various shades of pink, lavender, yellow and white - the last predominating. At Dhamra and at Dholpur Station yards I noticed beautiful pink sandstone flags sometimes speckled with white spots. Evidently there are large sandstone quarries close by. Some of the flagstones were 3 ft. x 8 ft. x 2" thick and appear to have been split from large sized blocks by the introduction of wedges along the perfect parallel laminations. A good many such massive blocks are being used in the construction of the new Imperial Delhi D₁₂₅ & D₁₂₆.

The Gondwanas.

Another important formation in Central Provinces yielding sandstone blocks in small quantities is the Gondwanas. In the neighbourhood of Borgaon and Adasa I saw the Kampti group of the Gondwana rocks consisting mainly of white pink grits and ferruginous sandstones. On the southern slope of Δ 1133 near the large N & S stream $\frac{3}{4}$ mile S.S.W. of Silori these rocks overlies pink and lavender coloured banded clays 3 ft. thick which in their turn rest upon coarse pebbly bed and gritty sandstone. The sequence of beds is repeated on the right bank of the tributary stream to Chandrabhaga river, 3 furlongs E of Dhurkhera. Here the beds have a pretty steep dip of 25° E. Usually they are horizontal. The pebbly bed is not more than 6" to 1 foot in thickness and rests on the sandstones irregularly eroded. The pebbles are chiefly of small sized quartzes and felspars and they are more or less rounded. The banded clays and sandstones are infossiliferous in this locality.

At Borgaon and on the Adasa temple hill Δ 1124, the

gritty

gritty pink and white felspathic sandstone layers which show a difference in texture and in false bedding, are separated by a dark ferruginous band $\frac{3}{4}$ " thick on the average (D_{22}, D_{23} & D_{29}). This band is not continuous for any long distance. Microscopically the minerals constituting the dark band do not differ from the other portions of the grits or sandstones. The structure also is similar. Only the band appears to be dark on account of the higher ferruginous nature of the cementing material.

Similar bands are found at contact of sandstone and clay beds on Silori hill. I am therefore of opinion that percolating waters charged with ferruginous matter deposited their contents along such of the bedding planes which separated dissimilar textured rocks, thereby discolouring portions on either side of the bedding plane.

Clay as a nodule or as a small elongated patch commonly occurs included in the sandstone D_{26} thus proving that there was not ~~the~~ complete separation of the clay and sandstone at the time of deposition.

Mention has already been made that owing to the extensive spread of the Deccan Trap flow considerable Silicification has taken place in the underlying rocks. The Gondwanas too have not escaped silicification. The upper layers of the Kamthee sandstone group are frequently chalcedonic D_{25} , but the bottom beds are not.

At the quarry sites near Borgaon the sandstone slabs are sold at 4 to 5 annas a cubic foot, and when delivered
 Cost. at Nagpur a distance of 22 miles the selling price per cubic foot is as much as 10 to 12 annas..

A good number of stone circles constructed out of huge blocks of sandstone are found in the vicinity of Borgaon. They resemble our "Pandava Kulis" in the Chitaldrug and Tumkur Dis-

Districts. I surmise these stone circles once served the purpose of cattle pounds during nights for itinerant dealers moving with their flocks of sheep or cattle from one place to another.

Besides the Kanthis, I was able to see other Gondwana rocks viz., the clays and sandstones of Jubbulpore age. At Jubbulpore practically one half of the town is on these rocks, while the other, on the Madan Mahal side, is on syenite and granite. It is not a surprise to find numerous pottery works and a glass factory located at Jubbulpore for the clays and sandstones found at the surface here serve as fine raw material for the manufacture of porcelain ware and glass.

The clays are free from grit and other impurities and are grayish or whitish in colour. There are good many plant impressions in them D/104. The clays are in beds often 6 to 15 ft. thick and are freely used in Pottery Works. The sandstones are also pure in places and without much refining are used in glass manufacture.

On a hill near the Gun Carriage Factory, close to which Messrs. Burn & Co's clay pits are situated, the Gondwana rocks, sandstones and fossiliferous clays are overlaid by (1) glauconite green sand D₁₀₅, (2) limestone 8 ft. thick having the Dinosaurian bones D/101-103 reported upon by Dr. Matley (3) mottled sandstone and Kankary limestone 20 to 30 ft. thick & (4) thin cap. of the Deccan Trap. Probably beds 1 to 3 are the Lametas, which will ^{now} be described.

* Vide Papers read by Dr. Matley at the Indian Science Congress Sessions 1919 & 1920.

The Lametas.

Immediately below the Deccan Trap and resting unconformably either on the Gondwanas or on the Archaen rocks direct are the Infra trappean rocks commonly known as the Lameta formation. At Jubbulpore close to the Gun carriage Factory the Lametas are sufficiently well exposed in cliff sections, overlying the sandstones and clays of Jubbulpore age (Upper Gondwanas). The rock sequence here has already been mentioned. The limestone band (8ft. thick) next to the greenish sandstones appears to be distinctly sedimentary and it contains the Dinosaurian bones D₁₀₁₋₁₀₃. The Upper band of limestone 20 to 30 ft. thick is often nodular and Kankary. It has a sedimentary aspect and it looks as if this limestone band has been subjected to chemical alterations by the infiltrating waters holding silicon and calcareous matter in solution. It is highly probable that the overlying Deccan Trap has supplied the solvents.

In the Bheemalgundi area below the Deccan Trap there is a horizontal massive band of limestone about 20 to 50 ft. thick which fringes the trap outliers for a considerable distance without a break. (Vide Maps Rec. G.S.I. Vol. and) Sometimes they are cherty. Dr. Fermor and others regard this limestone as the typical representative of the Lametas and have ascribed to it "a chemical origin, formed subsequently to the eruption of the Deccan Trap lavas, by the replacing action of calcareous and siliceous solutions upon the rocks underlying the trap". "In the Chhindwara District the limestone and the cherts have been observed to be formed at the expense of gneiss, pegmatite, marble and hornblende schist". In my opinion this change appears to be local. Although I have collected a few specimens D₃₀, D₃₁ & D₃₂ which clearly show the residual feldspars in the otherwise limestone rock apparently derived from a coarse pegmatite, still I consider the main

mass of the limestone to be sedimentary as in the Jubbulpore area. It is difficult otherwise to account for the uniform regularity and persistence and the constant thickness maintained for long distances by the bed at the same altitude below the Deccan Trap.

Further, at Bheemalgundi the lameta limestone directly rests on the Biotite gneiss without any intervening gradation rock showing the passage of the gneiss into the limestone.

The skeleton tree - 'Stercularia Urans' noticed to grow on the crystalline limestones and marbles in other parts of Central Provinces is also found growing markedly on the lameta at Bheemalgundi, thereby often affording a distinct clue to the location of the limestone horizon in the midst of the thick brush-wood and jungle.

The Deccan Trap.

As I did not spend much time in the study of the Deccan Trap, I am not in a position to give more information than what has already been said about it in the beginning of this report. Detailed petrological descriptions of the Trap and of the crater lets found in the basaltic bed of the Kulbehra river opposite the village of Shikarpur, Chhindwara District, are to be found in Rec. G.S.I. Vols. XLII and XLVII Pt.2.

Laterite.

It is remarkable that in the Nagpur Balaghat area there is very little of the laterite formation. At Sihora through the surface alteration of the phyllites or clay schists some laterite is formed. Examination of the rocks in the field shows that there is a downward passage from the lateritic mass at the surface to the phyllite.

Bauxite.

Bauxite.

At Katni close to the outer signal for East Indian Railway from Jubbulpore there are a few pits on a small rise for bauxite, which occurs here in bouldery masses like laterite, in the midst of the white clays of the Lower Vindhyan.

It is also found filling the cracks in the clays which are often discoloured red & yellow.

The bauxite boulder when broken displays whitish or brownish pisolitic aggregates of clayish material cemented together by silica. The cement is brownish in tint. When permeated by solutions containing red iron oxides the cementing material distinctly gets harder and ferruginous D₁₂₁ and the rock as a whole then shows a lower percentage of Alumina.

As at Sihora where through slight crushing nodular and pisolitic structures have been imposed on the phyllites, it is conceivable that here also the Lower Vindhyan clays have been operated upon in a similar manner resulting in the formation of pisolitic bodies of clay which have been compacted into large boulders. Through the alteration of the pisolitic aggregates in which the silica has been replaced by oxygen with the concentration of the alumina and iron oxide the secondary bauxites are formed.

Pure rich bauxites D/120 of this locality contain 58 % Al_2O_3 . It is well worth determining the Alumina content in the white clay directly below the bauxites.

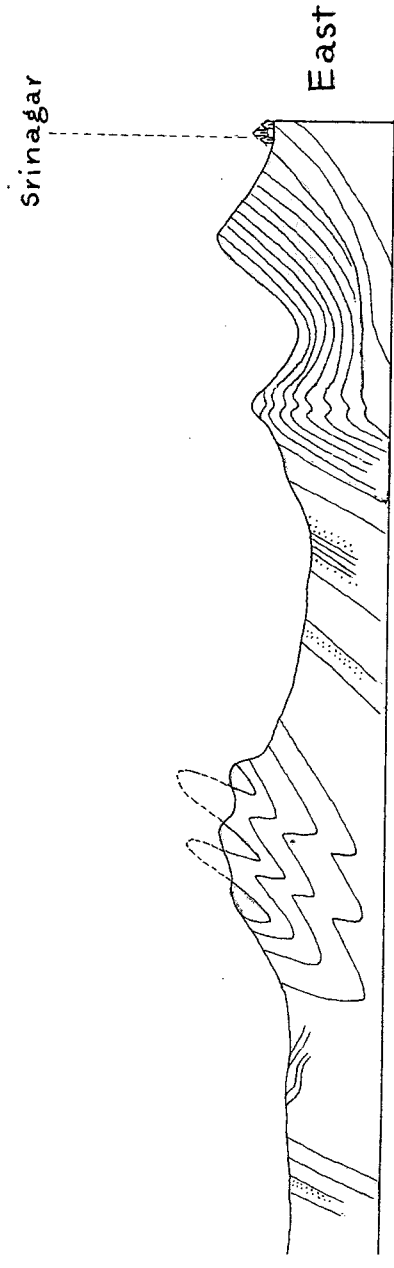
Alluvium - Older & Newer.

In the Chhindwara District there is an extensive deposit of older alluvium dark grey in colour composed chiefly of beds of sandstone and conglomerate - the latter containing pebbles of Deccan Trap. Kankar nodules and agate pieces are

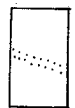
abundant

abundant. The recent fossils too are found and they are probably Pleistocene in age. This alluvium is often 20 to 50 ft. thick and occurs spread out more or less as an horizontal capping over the country obscuring the underlying formations. In the Ehemalgundi area it has evidently been deposited by the Kankhan river and her tributary streams on their flood plains in ancient times. The older alluvium is cut into by the present day stream lets and rivers and fresh deposit of Newer alluvium is in the course of formation. From their position on the field and from the difference presented by them it is possible to map the two alluviums separately.

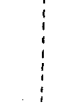
For nearly a mile or more on either side of the present river courses in North India, the grayish older alluviums which originally capped the ancient flood plains of the rivers are now being worked into easily by rain waters. They have given rise to very much broken up country well nigh impossible to cross and have also added beauty to the landscape with their grass grown pinnacles and crags. In other words, the country presents the appearance of deep cut 'canyons'. Uncompacted sandstone layers with subordinate beds of conglomerate and are the chief components of the older alluviums which can be seen to advantage in the neighbourhood of Beraghat Nerbudda river. From the older alluvium of the Nerbudda river several fossil bones of Elephants and other huge pachyderms have been unearthed.

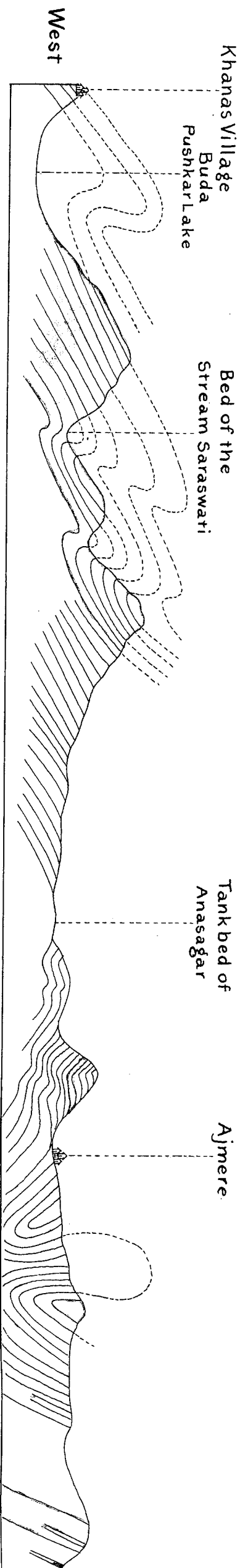


with Garnets and Staurolite



Quartz Reef





- Hornblende Schist
- Quartzite
- Gneiss (crushed)
- Biotite Mica Schist
- Biotite Mica Schis

Length of Section about 16 miles.

Rajputana.

Ajmere.

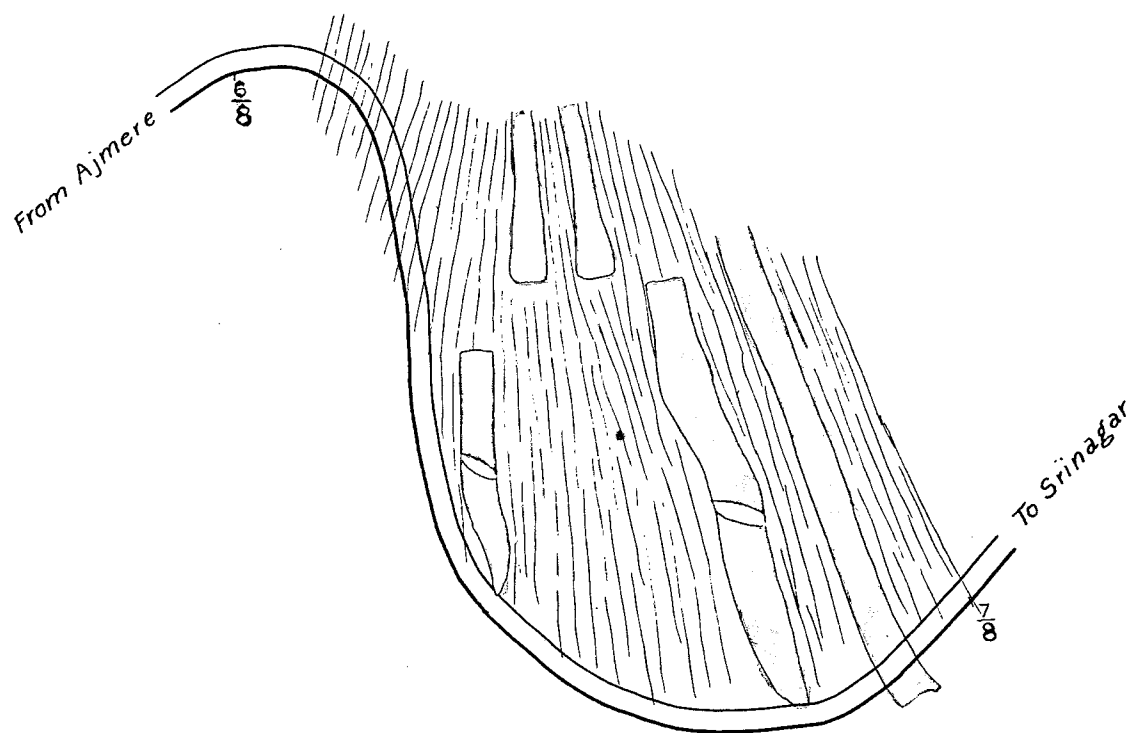
My next scene of activity in the study of Archaen rocks was Rajputana where in the neighbourhood of Ajmere I examined the rock outcrops across the strike for a distance of about 16 miles, from Srinagar to Ajmere and Buda Pushkar. The accompanying horizontal section (not drawn to scale) illustrates the disposition of the rocks met with in the area. It is evident ^{therefrom} ~~from~~ that they are intensely folded and denuded. Dip slopes and escarpments are common especially on the high ridge of Quartzites more or less in conformity with the prevailing strike of the rocks NNE to SSW. Dips are also high being 60° to 90° . The gneiss, which I consider to be the last in the sequence of formations here, has been folded anticlinally at the Anasagar lake. Similarly, along with the quartzites it has been sharply ~~folded~~ folded in the ghat section between the 7th and 8th mile on the Ajmere-Srinagar road, and in the valleys of the Buda Pushkar lake to the west. Besides the gneiss the rocks found in the traverse are the dark speckled Hornblende Schist D_{135} identical in appearance and in the mineral composition with the hornblende schist rocks in Mysore occurring associated with the Peninsular gneiss. At contact between the intrusive biotite gneiss of Aravallis and the hornblende schist dark brown biotite mica schist, D_{134} full of garnets and staurolite are developed at the 6th mile and between the 8th and 9th miles in road east of Ajmere. This is analogous to the garnet and staurolite biotite schist formation in the Hole Narsipur area in Mysore. From the way in which the contact minerals and the thin quartz veins of the biotite schists have been drawn ^{out} into lenticles in the crumples D_{134} it can be inferred that the rocks have been subjected to intense pressure and folding only after the invasion of the gneiss, the development of the contact minerals and the later intrusion

of the quartz veins.

There are a few thin caught up stringers of amphibolite D₁₂₉ in the gneiss, and these have given rise locally to some dolomitic limestones D₁₃₀

It is about the quartzite, styled by Mr. A.C. Hackett, 'the Alwar quartzite of the Delhi series' and regarded in his revised classification as a later member to the Aravalli series, that considerable difference of opinion exists. Mr. Heron who has recently examined portions of N.E. Rajputana criticises Mr. Hackett's revised conclusions and is inclined to accept the latter's original scheme of classification with certain reservations. A comparative table mentioning Mr. Hackett's two classifications, old and new, and that of Mr. Heron is given on page 106, Mem. G.S.I. Vol. XLV, Pt. 1. It is quite possible that both may be correct, the one arguing from observations of the crystalline rocks in the South and the other from the sub metamorphic sedimentaries in the North. While Geologists who have travelled far in the Aravalli regions are thus at variance it may be considered presumptuous if I were to offer any remarks on the origin and relative position of the rocks in the much disturbed Aravallis from a cursory examination of the rocks in the neighbourhood of Ajmere. However in the traverse I undertook I was fortunate enough to secure some evidences of intrusive contacts and Xenoliths which clearly establish the relationship of rock formations that are not far in their macro and micro characteristics from those occurring in Mysore. I have already mentioned instances of contact metamorphism and the development of garnets and staurolite in contact zones. While trying to find out the relative position of the gray quartzites capping the ridges and the comparatively darker

* c.a. Hackett Rec. G.S.I. Vol. XIV.
Ibid. Vol. X.



Gneiss----- Quartzite----- Quartz Reef-----

looking and slightly more micaceous quartzit~~y~~ rocks (crushed) gneiss D₁₃₁), forming the intervening valleys in the ghat section between the 7th and 8th miles on the Ajmere-Srinagar road, I came upon an outcrop of highly schisted portion of the latter having the former as caught^{up} inclusions. The exact spot where this ~~occurs~~ ^{occurs} is at the road side 20 yards before the 7th furlong stone of the 8th mile. The unmistakable Alwar quartzite veined by quartz reefs appears as thin caught up lenticles in the darker looking rock which I take to be the fine grained variation of the later intrusive gneiss of the region. The white quartz veins in the Alwar quartzite Xenoliths stop short at contact with the schisted gneiss (vide sketch Fig. 1.). Such facts make me think that the quartzites are caught up remnants in the gneiss. The several runs of quartzites in the area may not represent different bands, but may be the folded repetitions of one or two (vide horizontal section). I consider the relative differences in weathering and the isoclinal syncline folding of the rocks as being mainly responsible for the present position of the Alwar quartzites capping ridges.

The quartzites are highly jointed and they can well be seen as clefts or lines on escarpment slopes especially on the high hill to the west of the Ajmere Anasagar lake at Ajmere. At the foot there are several loose blocks of fallen fragments. Dendritic markings of manganese dioxide along joints are fairly numerous.

Microscopically there is not much difference to be noticed between the Delhi ridge quartzite D_{126A} and the Alwar quartzites (D₁₂₈, D₁₃₂, D₁₃₃, D₁₃₆ & D₁₃₈) capping the hills round about Ajmere. Both contain crushed irregular quartz, microcline with small dust like inclusions, and sparingly biotite and muscovite micas. In some sections tourmaline and

zircons are found. It is quite possible that they belong to the same series and are formed by the crushing of an old gneissic granite (allied to the Champion gneiss of Mysore). Further, they resemble closely the quartzites in C.P. in their structural and mineralogical characteristics.

The crushed dark biotite gneiss D₁₃₁ referred to above has much biotite and muscovite, quartz, epidote and zoisite and calcite. Microcline feldspars are wanting and there appears to be plagioclase feldspars though not clearly made out.

The dark biotite gneiss D₁₂₇, which I take to have intruded all the other rocks, exhibits near the bund at Anasagar lake a highly foliated pseudocomglomeratic appearance on account of the intense pressure and folding to which it has been subjected. The mica layers have been made to flow past the irregularly distributed and often lens shaped leucocratic folia. Both kinds of mica are present.

On a study of the rocks of the area I am inclined to consider the rocks in the vicinity of Ajmere to be typical representatives of the Dharwar of Southern India. The dark speckled hornblende schist, the amphibolites and the biotite mica schists with garnets and staurolites at contact recall similar rock occurrences in Mysore. The large extent of the quartzites (Alwar and Delhi series) capping ridges and which is distinctly older than the gneiss of the region, appear to correspond to the quartzose phase of the Champion gneiss. Lastly, the Aravalli gneiss which has distinct intrusive relations with all the foregoing members, it is in all probability a variation of the Peninsular gneiss.

Darjeeling.

In order to obtain an idea of Himalayan Topography and and to study the rocks of the Daling Series correlated with the Dharwars of Southern India, I paid a hurried visit to Darjeeling and its neighbourhood from Calcutta. The northern section of the railway takes one through a level bit of flat country which is periodically subjected to inundation of the Ganges and her tributaries. No rocks are visible, all being covered up by the alluvium. Siliguri, wherefrom starts the Darjeeling Himalayan railway, has an elevation of about 300 ft. and within a distance of 47 miles the mountain railway, winding in and out of the transverse valleys, doubling innumerable spurs and performing feats of looping the loop in the Sub Himalayan regions attains an altitude of 7407 ft. at Ghum. The Station of Darjeeling however is at a lower elevation of 7186 ft.

On the day of my travel, the 5th March 1920, the weather conditions were very unfavourable. There was a dense mist which was annoying as it effectively screened the scenery one would like to see. Towards the afternoon the sky was overcast with dense clouds. The temperature record was also low for at Darjeeling the thermometer registered 48° F. The next day at 11 A.M. there was ^a regular downpour of small rounded pellets of hail shaped somewhat like this for nearly fifteen minutes. The hill slopes of Jalpahar, and Senchal and the small village of Joregungalow close by, were covered with beautiful white hail which in places was 6 inches thick. I was right in the midst of this hail storm and for me it was quite a novel experience to handle the thickly strewn hail and press it into small balls which through regelation compacted itself hard. Immediately on arrival at Ghum Station I noticed the thermometer at 38° F. This precipitation of hail cleared the sky considerably and I was then able to see the high snow

clad Himalayan range for miles with the mighty Kinchinjinga and other peaks in all their magnificence and grandeur. In the foreground there were parallel range upon range of dark rocky mountains of the Sub-Himalayan chain covered with pure white snow at the top and with visible glaciers on the slopes ending more or less abruptly. Words fail to convey the impressions created on observing the reddish coppery glow of the snow on Kinchinjinga during sun set and the bluish and dazzling white appearance of the snow at sun rise. In the words of Rudyard Kipling "what is the good of writing impressions ? Every man has to get his own at first hand".

The Sub-Himalayan zone, which in this region I take to be from Siliguri to the Great Rungeet river, is composed of several E.N.E. directioned rocky hill ranges separated from one another by equally numerous deep parallel valleys in the same direction. Very many long narrow spurs with an almost N. & S. trend branch out of these ridges; with the tea-plantations and conifers and with the clearings in the midst of the otherwise thickly clad slopes, the spurs add beauty to the Himalayan scenery. The large rivers, such as the Great Rungeet and the Teista, after flowing for a considerable distance in an E. & W. direction at the base of the Himalayan along probably the main boundary fault unite and have a southernly course in the Sub-Himalayas, transverse to the prevailing direction of the ranges. Other streams also behave in a similar manner.

The entire region between Darjeeling and Ghyabari consists of highly crumpled and contorted biotite gneiss D¹⁵⁴⁻¹¹. The rock is well foliated. On the Senchal rise where the gneiss shows a dip of 40° N.N.E., drawn portions of the quartz feldspar folia appear as lens shaped masses in the midst of the biotite layers. This is quite a common occurrence throughout. At Mahanadi Station where the rocks have been

subjected to intense crush and shear leucocratic portions of the gneiss present a pseudo-conglomeratic appearance. In such shear zones garnets, sillimanite and sericite mica are largely developed. Microscopically Darjeeling gneiss. (D_{154} & D_{155}) is composed of strained and crushed quartz, plagioclase, felspar, dark brown highly pleochroic biotites some showing intense absorption, muscovite and a few pink garnet and magnetite. There are very few accessory minerals.

Towards the southern end, at Chyabari Station, the highly crushed gneiss becomes intensely micaceous and resembles mica schist. This has thin caught up runs of coarse speckled hornblende schists D_{158} and D_{159} . The microsection of these hornblende schist rocks are not unlike Lingadhalli Trap rocks with the bluish green pleochroic hornblendes, and epidote, felspar, iron pyrites and magnetite. The strike of the rocks is 20° N. of E with a dip $N. 75^{\circ}$. At the Ghyabari Tea Estate is the junction of the micaceous gneiss and the dark fissile argillite D_{161} & D_{162} , which on weathered surface presents a grayish Cherty appearance. The latter in the several crush zones is highly fissile like dark slate and is slightly graphitic. Dolomitic limestone bands occur sparingly in the middle of the argillite. The whole of the schist facies here resemble the feldspathic grits and argillites of the Champion gneiss series in Mysore, and probably are derived in the same way and hold a similar stratigraphical position. The argillites, and limestones with the thin runs of hornblende schists and ^a portion of the gneiss which has become mica schists have been styled the Daling Series and are regarded as sedimentary rocks. As far as I could see in this traverse there is nothing in the schists to indicate a sedimentary origin.

The rocks being highly fissile and jointed with a dip angle of about 80° N, there are occasional landslips along the

dip

dip slopes between Ghyabari and Tindharia. In the cart track near a loop in the Railway between the two Stations mentioned above there is a huge stray boulder of enidotized felspar and quartz very compact and hard. It resembles a felspathic quartzite and the rock is highly jointed.

200 yards N. of Tindharia Station is the abrupt junction of the felspathic sandstone of the Damudas and the argillites of the Daling Series. The former dip under the latter. ^{*} the result, I believe, of an inversion. The Damudas are well exposed in a cliff section 2 furlongs from Tindharia Station whereat the loco offices are located.

I give below the section observed from bottom upwards:-

- | | | |
|------|---|--------------------------|
| (1) | Yellowish brown micaceous sandstone (D ₁₆₃) | |
| (2) | Dark Carbonaceous Shale D ₁₆₄
do. slightly micaceous D ₁₆₅ | 3 feet. |
| (3) | Anthracite coal (Schisted) | 1½ ft. |
| (4) | Carbonaceous Shale. | 3 ft. |
| (5) | Coal Seam similar to (3) | ¾ ft. |
| (6) | Sandstone similar to (1) | 15 ft. |
| (7) | Anthracite coal (glistening seam) D ₁₆₆ | 3 ft. (Specimen missing) |
| (8) | Whitish sandstone (felspathic) | 18 ft. |
| (9) | Coal. | 1 ft. |
| (10) | Sandstone to top of rise. | 4 to 8 ft. |

The coal seams are probably the same noticed and reported upon by Mr. Mallet in the Tindharia ravines close by. If so, the coal on analysis has proved to be free from sulphur and phosphorus, has 12 per cent of volatile matter and 66.3 % of free carbon. The total thickness of the Damudas in this

locality is not more than half a mile. The strike of the rock is E.N.E. with a gentle dip of 25° N.N.W.

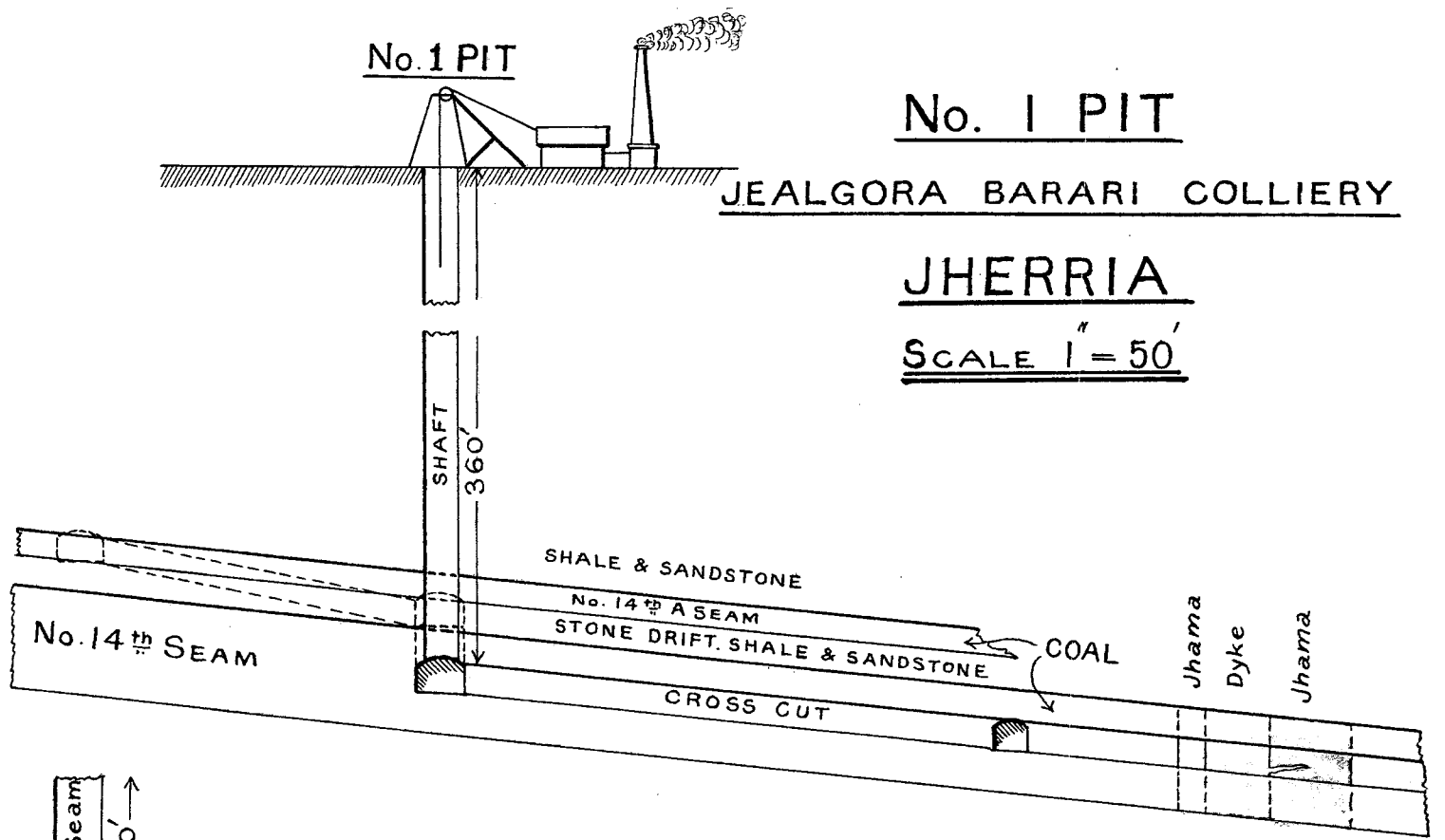
I did not pay any attention to the Nahan group (Tertiaries) as they are not well developed in this section. Neither did I visit any of the copper localities in the Darjeeling territory for they were all far away in the interior. It is a significant fact that the ore, which is copper pyrites, is all known to occur in the Daling beds with the exception of some copper ore near Buxa in the rocks of the Buxa Series.* This is in complete harmony with my findings in the Singbhum District to be described later on, where the copper ore also occurs in rocks similar to the Champion gneiss series.

* Ibid

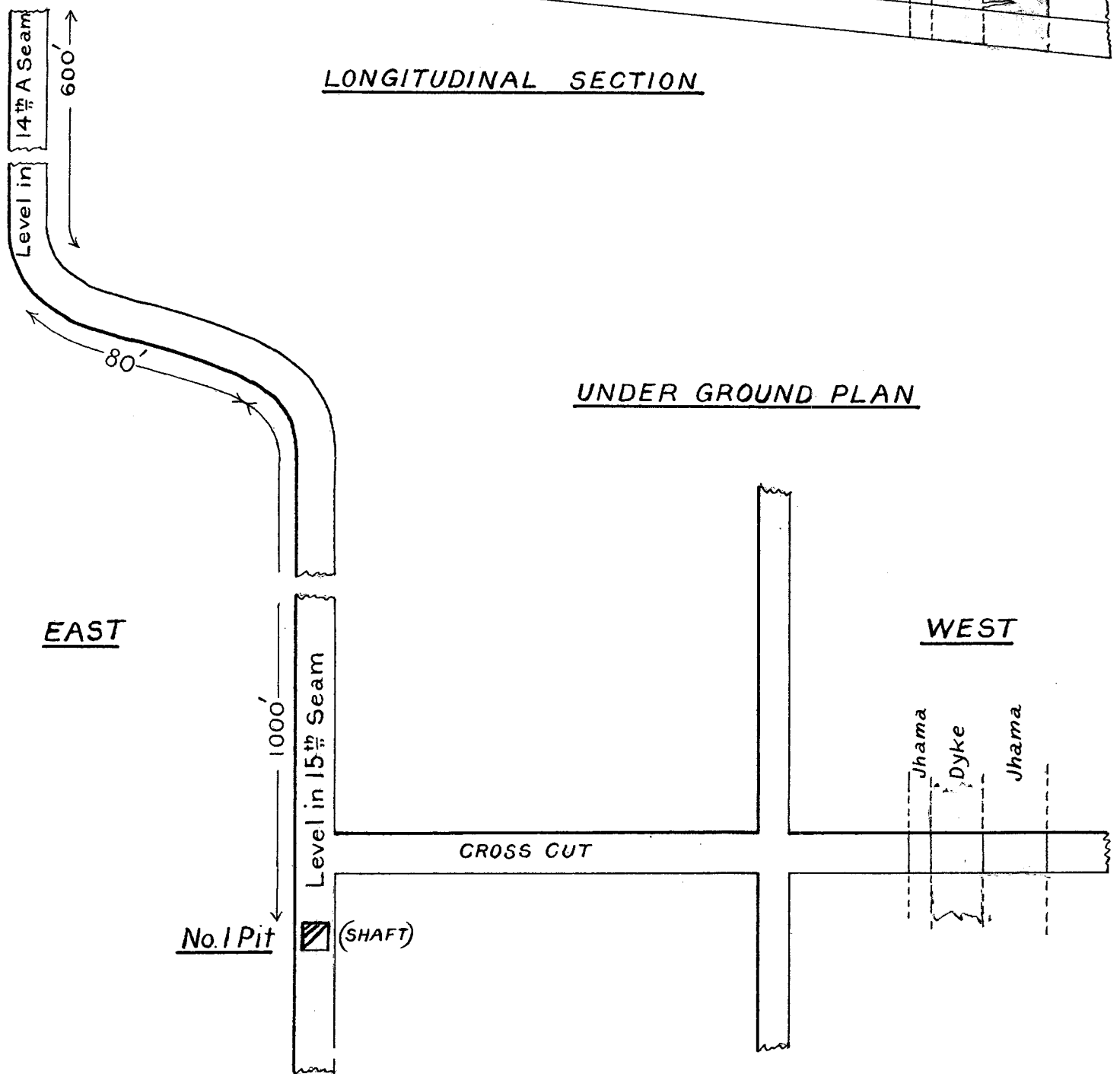
Barari Colliery Jherria Coal Fields.

Through the kindness of Mr. Mason, the Ag. Manager of the Barari Colliery I was able to see the occurrence underground of the Barkar Coal Seams Nos. 14 A & 15 and to study the contact metamorphic effects of a basic dyke intruding the latter in No. 1 pit Jealgora (Vide section & underground plan). At the 360 ft. level the No. 15 Coal Seam D₁₄₁ 28 ft. thick is encountered. The width of the drive along the seam is 15 ft. in a N & S direction for a considerable distance on either side of the vertical shaft. There is also a crosscut west along the dip of the Coal Seam 1 in 10 for a distance of over 250 ft. In this cross-cut about 210 ft. from the shaft there is a basic dyke, also N & S directioned, which clearly and unmistakably has intruded the Coal Seam. It has also sent out a thin branch to the west. The contact metamorphic effects both on the Coal Seam and on the dyke are very pronounced. The shining metallic lustered anthracite coal of No. 15 seam is fritted out into a cindery coke mass, called 'Jhama' by the Miners, for a distance of 7 ft. from the edge of the dyke to the East and to a distance of 24 ft. to the west. The dyke has developed much pinkish biotite mica at contact and is also bleached white. The following specimens taken from the contact zone illustrate the above phenomena clearly.-

D₁₄₅. A compact heavy dark gray basic dyke, with numerous brown biotite flakes. Under the microscope plates of highly pleochroic red brown to wine yellow biotites having micaceous dark inclusions lie in an indistinguishable fuzzy groundmass of kaolin, sericite & calcite and leucoxene granules. The specimen was obtained from the centre of the dyke.



LONGITUDINAL SECTION



D₁₄₆ is the same rock more grayish and micaceous taken from the edge of the dyke mass. Similar to the above microscopically.

D₁₄₇. The actual contact rock. The whitish altered dyke has sent out thin veins into the dull looking coke.

D₁₄₃. This is a very interesting specimen. The gray dyke has numerous caught up pieces of the coal which it has converted into dull coke. In places it has also fused the coke to a shining mass.

The section shows centres of dark opaque substance (Coke) which has numerous rounded grains of quartz or secondary silica, another lie in a dull very much altered groundmass of quartz, Kaolin, felspar &c. &c.

Overlying the No.15 Coal Seam are 7 ft. thickness of what the miners call 'Stone drift' consisting of shale D₁₅₀ with fossil impressions, sandstone D₁₅₁ and shale striking and dipping in the same manner. Conformably overlying all these is the No.14 A Anthracite Coal Seam D/130 & 140-7 ft. Here I noticed pillar cuttings in coal. There were in the Sea seam nodular chunks or 'Clay balls' D₁₄₈ having spore like brown granular aggregates in them. Projecting from the overhanging shale bed in the drive I found a big sized 'Clay ball' D₁₅₃ which must therefore have been irregularly lying in the No.14 A Coal Seam. The micro section of this resembles that of the ~~Barkar~~ Barakar Sandstone, only there are numerous round or oval yellowish or brownish patches not unlike the granular spores of D₁₄₈. The bottom portion of this nodular piece exhibits a grooved and striated coal surface (Slickenside).

Singhbhum District.

In the newly constituted division of Behar and Orissa, the District of Singhbhum appears to be specially favoured by nature with a variety of minerals of economic importance, such as Gold and Silver, iron and manganese ores, chromite, copper ore pyrites, wolfram, apatite and magnetite, not to mention^e of asbestos, mica, talc and limestone. A number of them are being turned into good account. Of those that are worked on a large scale, I visited (1) the iron ore deposits at Duia, 14 miles from Manharpur, the property of the Bengal Iron & Steel Co., (2) the chromite deposit at Jojhatti, 16 miles west of Chaibasa, owned by the Singhbhum Singhbhum Chromite Co., Ltd., (3) the asbestos deposits at Chota Bana, Seraikela, and (4) The Raka Copper Mines near Galudih of the Cap Copper Co., Incidentally I devoted some attention to the associated rocks as well.

Dr. Fermor, in discoursing on 'some problems of Ore Gneiss in the Archaens of India'⁺ classifies such ore deposits into 3 groups, Viz.-

- (1) the syngenetic sedimentary deposits of the Dharwars exemplified by iron and manganese deposits;
- (2) the syngenetic igneous Post Dharwar deposits exemplified by chromite deposits in Peridotite; and
- (3) the epigenetic ore deposits (mainly in the Dharwars) due to granitic intrusions exemplified by lodes of copper, lead, zinc, gold, &c.,

and applies the same grouping to the ore occurrences in the Singhbhum District. While subscribing more or less fully to the views advanced by Dr. Fermor regarding the mode of formation or origin of the ore bodies in the Singhbhum District, I

* Ball Ec. Geology Pt. III & Fermor Pr. Address to the Geol. Section, Sixth Indian Science Congress, Bombay, 1919.

beg to differ from him, for reasons already mentioned in connection with the rock descriptions of Balaghat (Chilpighat Series) and of Sihora area Central Provinces, in considering the associated shales, phyllites and mica schists as being no Dharwars but probable Cuddappas. More than in Balaghat and in Sihora, the rocks of the Singhbhum District present a highly sedimentary and less metamorphosed aspect D₁₆₇ D₁₇₉, and differ considerably from the typical crystalline schists - the Dharwars of Southern India. It is only in a few places as in the Koel river at Manharpur and in the Subarnarekha river at Galudih close to the margins of the schist belt and that too to a limited extent, I noticed hornblende schists and amphibolites. In the former locality such crystalline schists having a strike of 20° to 35° N of E and Dip 45° N.N.W. are intruded by schistose gritty rocks - D/177 - that are not unlike the crushed phases of the Champion gneiss series in Mysore. There is also a large bouldery brecciated mass of amphibolite, quartz and epidote veins (D 176) in the bed of the Koel river at Manharpur.

The Iron Ores at Duia.

The extensive iron ore deposit on the Lutuburu Δ2583 ridge running in an almost NNE & SSW direction, due east of the village of Duia is owned by the Bengal Iron & Steel Co., Ltd. The place is connected with the main B.N.Ry. close to Manharpur by a metre gauge railway line, 14 miles long. Where the latter crosses the ^{Koel}~~Koel~~ river, the height of the place above sea level recorded is 946 ft.

It is remarkable to note here the preponderance of the dark gray shale or phyllite which to a great extent is gritty and micaceous. At the base of the Lutuburu hill this dark phyllite has a distinct strike 20° N of E Dip 60° N.N.W., but half way up the hill the direction changes to 30° E of N Dip W 80°. The same strike and dip continues to the top,

where the phyllites distinctly alter and give rise to the ferruginous and haematite schists and iron ore masses. Further, alteration has resulted in the formation of lateritic boulders. Every gradation from a dark gray phyllite to a laterite can be seen in specimens D₁₆₇ to D₁₇₄ all obtained from the iron ore hill. The formation is not unlike the Kemmangundi iron ores and laterites. The iron ore of Duia formed in a manner similar to the manganese ore deposits of the Balaghat area occupies a zone a few feet thick on the top of the ~~80~~ hill ridge and is being worked systematically in benches. The quarried ore from the top bench is tipped on to the lower along steep inclines. Here it is collected and transported in trucks to the large bin, capable of holding 500 tons, located on the west slope of the hill about 200 ft. from the summit close to the aerial ropeway top station. The ore is transported to lower levels (974 ft down) by means of an endless aerial ropeway 3300 ft long. The steepest incline is 1 in 2 while the average gradient is 1 in 3. The carrying rope is supported on 5 standards or posts the tallest of which is 150 ft. high. The hauling rope passes round a large grooved wheel spinning on a vertical axis at either end. To keep the mechanism in tension balancing weights to the extent of 3 cwt are attached at the ends.

The total number of waggons running on the ropeway is 35 with a carrying capacity each of about 1/3 ton. The two grooved pulleys of each wagon run on the carrying rope while the bottom curved clutch catches the hauling rope. The force of descent of the loaded trucks on the right impels the empties to come up on the left. An ingenious but simple contrivance fixed at each terminal station raises or lowers the two pulleys of each wagon as it passes by and thus throws it on to or off the carrying rope. At the same time the clutch is released and the moving wagon passes on to a stout iron rail. In this manner the waggons escape contact

with

with the large terminal wheel at the station.

In order to study the motion of the large wheel at the top end, around which the 3 strand hauling rope moves automatically by the force of gravity of the loaded trucks there are 3 brakes - an hand-brake, an hydraulic brake and a pneumatic brake. The handbrake acts directly on the wheel and is the one used for sudden and complete stoppage when an emergency arises. The other two brakes working automatically are intended to check the rapid rotation of the wheel. The vertical axial rod of the wheel having a bladed arrangement at the bottom rotates in an hollow iron cylinder or (bottle) full of water and churns it. An indirect check to the rapid rotation of the wheel is thus imparted and the aerial ropeway slackens speed. Similarly the slight closure or opening of the lid of a box, wherein an electric fan is working by the aid of a dynamo, imparts a reverse motion to shaft arrangements attached to the axial rod of the wheel and thus pneumatic check is brought about.

The loaded tipping waggon on approach of the bottom wheel are tilted, and the iron ore gets into a large bin of 1000 tons capacity, wherefrom through the opening of shutters the ore body is taken straight on to Railway waggon ready for transport. The capacity of each railway waggon is $4\frac{1}{2}$ ton and a train is formed of 20 such waggons. During the day 5 trains run from Duia to Manharpur. I am informed that on an average the ore sent out to the Company's works at Kulti in the District of Burdwan, E.I.Ry., borders on 700 tons per day.

The work of extracting the iron ore is entrusted mainly to contractors who pay labour at contract rates of 13 annas 3 pies per ton of ore collected and stacked. The Company when they engage labour and get the work done, pay wages at 6 annas

per man and 4 annas 6 pies per woman per day. On account of the disturbing monsoon rains (Rainfall 40 inches), every year for about 2 months in June and July all work is practically at a standstill. On an average work is being carried on for 300 days in a year on 2 shifts⁶ per day - one from 8 to 12 noon and 2 to 6 P.M., and the other from 6 to 12 P.M. and 6 to 8 A.M. The total production of ore is about 100,000 tons per annum.

The labour colony at Duia is 250 strong and at Chiria it is about 100. The Company has provided them with decent quarters hospital and a school. Every comfort of the labourer has been properly attended to.

Chromite deposit, Jojohatti.

My next visit was to the chromite workings at Jojohatti, 16 miles west of Chaibasa, in the middle of a fairly inaccessible jungle. There is, however, a decent road which passing Barkela connects the place with Chaibasa.

The Singhbhum Chromite Co., are the owners of the property and the business management is entrusted to Mr. L.A. Shragger. The place selected for the camp offices is on a small ridge of quartzite which appears to be a phase of an intrusive granite in the middle of the phyllites and the ultrabasic intrusives. On account of the sharp almost circular folding of the rocks at the place, it is difficult to determine their relative positions. But in my hurried traverse I was fortunate enough to come upon two or three contact zones wherefrom it can be made out that the country rock which happens to be the sedimentary phyllite gray or red (strike N.W. or 20° N of W Dip Northwards) has been intruded by the ultrabasic rocks D/185, D/187 "chiefly enstatite, ~~per-~~ peridotite or saxonite with subsidiary pyroxene, Iherzolite and dunite.* All these appear to be invaded by the quartzite

* Fernor Proc. As. Soc. Bengal Vol. XV 1919 No. 4

mentioned above.

The chromite occurs as very thin irregular veins in the bouldery saxonites (called the 'Kankhan' by the miners) at Karakatakuti hill and at Bungamund and Bangatiwara. In one of the workings on the Karakatakuti hill there was a 6 inch thick horizontal chromite vein which appeared like a bedded deposit in the also horizontal saxonite. But this, I consider, to be the outcome of a local disturbance. The numerous chromite pits on this hill never show greater depths than 10 to 15 ft. The occurrence of the ore body is such that a great tonnage cannot be expected from this area, and the rough estimate I was able to make borders on 5000 tons. Most of the ore collected so far appears to have come from the surface pebbles.

At the K₂ mine (Karakatakuti) the ore is crushed fine to pass 20 mesh screens by tamping with steel rods on steel plates. Then it is bagged and sent to a washing place close by in the Anjedberu Forest, where it is concentrated being freed from impurities. It is contemplated to introduce crushers to crush the chromite fine and then make bricquettes out of them on the spot. The ore now got out from the mine has 50% Cr₂O₃ and about 12 to 14% Fe. Mr. Shragger informed me that there was a good demand from Chromite manufacturers in Calcutta and that they were purchasing the chromite delivered there at Rs.75/- per ton.

As in other parts of the Singhbhum District contract work is in vogue even here. The contractor is paid Rs.17/8 for 1000 cubic feet of hard rock excavation and Rs.12/8 for the same quantity of earth work excavation irrespective of ore body found. In the event of his stacking 100 cubic feet of ore at the foot of the hill he is paid Rs.9/8 extra for every such heap. The daily wages earned by a man cooly at Jojonatti

is 4 annas and a woman cooly is 3 annas.

In company with Mr. Shragger I visited the abandoned chromite workings of Messrs. Schroder Schmidt & Co., to the east of the camp, in the altered dunite rocks. The pits are very large and they are also mostly filled up. I was not able to see any chromite veins in any of the pits. The chromite pieces lying about are dark, have a metallic sheen and have circular or oval dark spots in the granular chromite aggregates as if there were local compacting D₁₈₉. The serpentine derived from the alteration of the Dunite is green and very beautiful to look at with the chrysotile variations. The rock may be turned to some account as a building stone since it occurs in fair abundance. In this area there is the marginal silicification of the ultrabasic rocks, as well as the formation of Kankar nodules from saxonite and Iherzolite alterations. In places the rocks weather reddish brown and yellow D₁₈₅.

Due South of Basuberu village and about a furlong from it, in a bend of the road, I observed a clear case of intrusion of a 20° E of N directioned Cherty felsite D₁₈₀ (not unlike the felsite member 'Apophyllite' of the Champion Gneiss Series) into the dark phyllite country rock which showed a 20° N. of E. strike. Exactly at contact the phyllite assumed a Chloritic D₁₈₂ and dolomitic D₁₈₁ aspect. Again between Hesanabad and Jojohatti in road is another interesting junction of the 20° E of N Felsite and the phyllite. Here the phyllite shows signs of baking and conversion into green chloritic schists with Chalybite. On the west side of the Felsite after the chloritic schist for a distance of about 150 yards it is biotite schist, and then the normal country rock - the phyllite - makes its appearance. The so called phyllites are mostly muddy schists dark grey and lavender coloured. The

51.

specimen D₁₇₉ was from an outcrop 100 yards from the road
branching to Jojohatti from the Barkela Forest road.

The asbestos deposit, Saraikela.

On hearing a report that beautiful white asbestos is found in the Native State of Saraikela, I proceeded to that place from Chaibasa with the object of studying the mode of occurrence of that mineral. After obtaining the kind permission of the Raja Sahib of the State, conveyed to me through his Private Secretary Mr. N. Mahanty, I went to Chota Bana 6 miles S.E. of Saraikela, where in a water course at the foot of a small rise, I saw nearly 350 men and women coolies (employees of Mr. Jenmi Doss of Empress Mills, Nagpur) engaged in removing asbestos from a large open excavation 50' x 30' : 5' (deep). The country rock wherein asbestos occurs in thin irregularly disposed horizontal layers 1" to 6" thick, happens to be a decomposed coarse tremolite enstatite rock, greenish in colour, and highly altered into bastite and serpentine. Magnetite streaks mostly secondary are noticeable in the section - D/194 and 195. In places the rock has a spotted appearance and its tough bouldery nature gives one the idea that it is an altering dyke rock. Close by are two parallel Norite dykes (Charnockite ?) which have idiomorphic and rectangular crystals of hypersthene and enstatites hastitizing, pale green diallage often clearly twinned, some cloudy feldspars having poecilitic diallage, brown biotite and ilmenite - (D/198 and D/198 A). The region in the neighbourhood is riddled with a number of such dykes.

The asbestos which occurs mostly in horizontal cracks and fissures as an alteration product of the magnesian silicate minerals of the ultrabasic tremolite enstatite rock, is highly mixed up with secondary silica and hence forms tough mountain wood (D/197 & D/197 A), which is practically useless. The large pieces are stuck up as posts to indicate approaches to the deposits. Here and there the asbestos is of very good quality being soft, fibrous and white. It comes

out in long strands - D/196. It is decidedly superior to Mysore Asbestos; but judging from the nature of the deposit, it looks as if there is not much quantity - a good deal of it being of the mountain wood variety. Good quality of asbestos to the extent of about 1000 tons may be obtained from this field.

The cooly rates are low being only $3\frac{1}{2}$ annas for a man and 3 annas for a woman.

It appears Mr. Jenna Doss, who has obtained a license to work the deposit, has promised to pay a royalty of Rs.75/- to the Raja Sahib of Saraikela for every ton of asbestos removed from his estate. For experimental purposes, about 100 tons have been allowed to be taken out.

At Saraikela in the bed of the Kharkai river is a dark epidiorite dyke intruding the grayish and slightly yellowish green epidotized granite rock (granophyre ?) which extends over a large area in the Singhbhum District. A section of this granite - D/200 - shows streaks and patches of sericitized feldspars and crushed quartzes with green chlorite, apatite and secondary epidote. The hand specimen of the rock ~~wa~~ resembles some compact varieties of the Champion gneiss series in Mysore, viz, - the coarse varieties of the Sulekere felsites.

While here, gloomy reports of the happenings at Jamshedpur (Sakchi) connected with the labour strike reached me and I was credibly informed that practically all work was at a standstill. It was unfortunate that the period of my visit to Singhbhum synchronised with the time of strike at Jamshedpur. Since I was advised by Government officials and others not to go there at this juncture, I gave the town a wide berth and proceeded to the Raka Copper Mines, Galudih. Thus I missed seeing the most important centre of iron smelting

The Raka Copper Mines.

The occurrence of Copper Ores in the Singhbhum District was undoubtedly known to the ancients for "Indications exist of mining and smelting having been carried on in this region from a very early period". "The number and extent of the ancient workings testify to the assiduity with which every sign of the presence of ore was exploited by these early pioneers". The old workings apparently lie in a zone or belt approximately parallel to the N.E. & N margins of the intrusive granites and granophyres in the Singhbhum District. It is reported that all lie within four miles or frequently within one or two miles of the intrusive acid rocks except at the S.E. end. Dr. Fermor who has carefully studied the occurrence of Minerals in this District is of opinion that the deposits are epigenetic in origin and are due to granitic intrusions.

Through the kindness of Mr. Mc Dermott, the Superintendent of the Raka Copper Mines near Galudih I was able to see the underground and surface workings. Close to the mine office is an incline shaft 60° to 70° along the dip N.E. to a depth of 900 ft. The shaft is well timbered and cages run up and down on rails. For the 1st 250 ft. ladders with wooden rungs are provided beyond which the ladders have steel rungs. The first horizontal level is at 150 ft. and the subsequent levels are 100 ft. apart. I examined the ore occurrence in the 2nd and 3rd levels. Rock drills worked with compressed air in an upward stoping in the 2nd level on the S.E. side bring down the ore body, while in a stoping along the incline on the north side of the 3rd level coolies were drilling holes in the lode matter with hand jumpers. It appeared to me that reef quartz 9" to 2' wide intruding a crushed micaceous gneiss

* Ball Economic Geology Page 248.
 Proc. Asiatic Society of Bengal Vol. XV. 1919
 Page clxxxviii and Plate II.

D/203 (more or less quartzite in appearance) was responsible for the Chalcopyrite and Erubescite found in the mine. The quartz lode or reef in the middle ^{carries} ~~carries~~ the 1st quality ore D/201, while the adjacent rock on either side called by the miners 'Rest' D/202 (which means the rest of the ore body - 2nd grade - left behind after the rich quartz lode is removed) is also slightly impregnated with the ore to a varying distance of 4 feet. Sometimes iron pyrites and magnetite are found associated with the ore in the Rest. This occurrence of the copper sulphide ore in thin quartz veins penetrating a crushed micaceous gneiss not far from the margins of granite intrusives is analogous to the iron sulphide ores (Iron pyrites) found in the Shimoga and Kadur Districts in the auriferous quartz stringers that lie in a zone or belt in the altered Champion gneiss series of rocks within a mile or two of the intrusive Tarikere and Shimoga gneiss or granite.

Both the quartz lode matter and the Rest are being ~~mined~~ mined at Galudih, but they are treated afterwards differently as the former contains 10% and the latter 1 to 4% copper ore.

The 3rd level exposes a crumpling in the Rest and the quartz reef in the middle is either drawn out into lenticles or is crushed into small pebbles nearly resembling an auto-clastic conglomerate. In parts of the 'Rest', chlorite is developed.

Water is being pumped to the surface by a Dynamo working in the 3rd level. I was told that another set pumps water from the 6th to the 3rd level.

Most of the drilling and excavation work underground is done by coolies who have come from ^{the} Central Provinces and ^{the} United Provinces. Each coolie who handles the hand jumper is paid 7 annas for drilling a two feet rod hole; and since he gets through 2 such holes or more in a day he earns 14 annas

or more. It is curious to note that all the skilled work such as timbering &c. is being done ~~from~~^{by} persons (Tamilians) who have gone up there from Mysore and Vellore. I was told there were as many as 300 such persons who have practically settled there from a long time with their families. The Timber Maistry is paid Rs.2-6-0 per day and the others Rs.1-6-0 or so according to the nature of the service they do.

The ore on coming to the surface in the case is tipped on an incline constructed out of iron rails set like a grating 3 to 4" apart. The fine pieces get down to a storage bin through this grating while the large pieces fall to a platform at a lower level where they are wetted by water and sorted about roughly by women into 1st and 2nd quality Ore.

The richer 1st quality lode matter is crushed into small pieces and is fed direct to the blast furnace. The 2nd sort is first sent to the Mill house where it is crushed small by rock crushers that are fed from the slowly revolving and differently perforated hollow drums upon which jets of water are constantly playing. In this manner the different sized ore material gets sorted first and then crushed in suitable crushers untill all is well pulverized and mixed with water into a slimy mass. This ^{is} well mixed up and if necessary pumped up to a large circular storage tank 20 ft. diameter where a 4 ft. thickness of sediment can collect. Otherwise the slime is passed on to a series of Jigs which separate the metallic ore particles from the rock materials. The former is then collected under jet washings and sent to a sintering pot (3½ ton capacity and having a rack and pinion arrangement for reversing) where it undergoes thorough heating in air-blast for 6 hours and is converted into Kinker ? Clinker. At this stage it is passed on to the Blast furnace along with the fluxes, ore &c

The Blast Furnace which is water jacketted and whose capacity for a full charge at a time is 40 tons, is being charged on and off during the 24 hours with 1st class copper ore, Kinker, iron ore (from Gurumashini) and limestone (from Panposh) all to the extent of 150 tons. The proportions of the charge mixture are determined by the experienced smelter on the assay values of the ore to be treated. Usually I was told 700 lbs. of Cu ore is mixed up with 850 lbs. of Fe ore and 690 lbs. of limestone to make up the 2240 lbs. or 1 ton charge. Coal is also used. The air is forced into the middle of the charge and a temperature of 1500°C is attained. The gases evolved from the Blast furnace are led on by a bent top flue to a cooling chamber built of brick and mortar which is ~~comple~~ completely sealed up except for a chimney at one end to allow the waste gases to escape after depositing small particles of Copper Ore inside the chamber. Practically very little ore is collected thus. The main bulk of the copper ~~ex~~ ore is in the 'matte' which is about 50 % of the charge and this issues out of the Blast Furnace on one side, while the slag comes out on the other.

The 'Matte' when of sufficient quantity is removed to the Converter heated by compressed air. The converter is an irregularly shaped retort having a circular bottom and a large opening at the top for the ~~escape~~ escape of gases into flues. The 'Matte' is converted into blistered copper. Just at the time of my visit I witnessed the tilting over of one of such converter and the pouring of the red hot molten liquid copper into large steel moulds. After a little cooling they are beaten out by men with large hammers into blocks called "The Pigs" and passed on to the Refinery for being made purer.

The Refinery which is located in an adjoining large building is of the usual baker's furnace pattern slightly arched in the middle both at the top and at the bottom and

with

with a side chamber for firing in the coal. There is an arrangement for updraught air current which leads the coal gases generated over the copper 'Pigs' charged in the Refinery oven, for the removal of impurities. For a charge, 150 'Pigs' weighing 17 tons are used. These are subjected to 12 hours heating during the night and in the early morning 5 strong men working for 4 hours ladle out all the molten liquid into moulds wherefrom after cooling the purified copper ingots (each weighing 38 lbs.) are removed and stored. Out of the 17 tons charge of 'Pig' about 14 tons of purified copper ingots are realized. The remaining 3 tons of impure scum or slag are removed again to the blast furnace for smelting.

The Superintendent, while according ^{me} permission to visit all parts of the Plant, specially asked me to treat any information that I may obtain confidential. When I informed him that the Government expected me to submit a report of my activities during the period of deputation he desired me to request Government, which I hereby do, not to give publicity to my report about the workings of the Rake Copper Mines.

Chipurapalli area.Kodurites & Khondalites.

Since the period of deputation was drawing to a close, I reluctantly left the geologically interesting Singhbhum District in order to make, even though it be, a passing acquaintance of the Kodurite and the Khondalite rocks in the Vizagapatam District. I fixed upon Chipurapalli, as it was a most convenient centre to study these formations and the associated Gneissose granites which were all well developed in this neighbourhood.

The name Kodurite is given by Dr. Fermor to a series of igneous (plutonic) intrusives in the Khondalites and the calcareous gneisses. "The type rock of the series is (considered to be) one composed of potash felspar, manganese, garnet (spandite), and apatite with or without pyroxene; and every gradation has been worked out from the acid quartz orthoclase rock to the ultrabasic graphitic manganese pyroxenites to fit in with a scheme of classification."

The occurrence of the more basic rock, such as the spandite rock surrounded by zones of less basic composition such as Kodurite in a general matrix of quartz felspar rock or felspar rock in the Kodur mine is regarded as the result of magmatic differentiation before intrusion. The various varieties of vein quartz and pegmatite intimately associated with the Kodurites in the Kodur Mine and their small extension not however continuous for any length are attributed to the breaking up of more extensive veins by the slipping of the masses of lithomarge; and it is even hinted that they

* Mem. G.S.I. Vol. XXXVII. pp. 249-250.

may be the most acid variants of the Kodurite series. The formation of the manganese ore bodies in the Kodurites are considered to be due to "hot mineral waters which attacking the manganiferous rocks took the manganese in solution and carried it to the another part of the rock mass where it was deposited so as to replace all the minerals of the rock, except those containing manganese which in some cases remained fresh and unaltered and in others were also broken up." Further in most of the spandite rocks it is reckoned "that the lime, alumina and silica were carried away leaving a porous mass of iron and manganese oxides which was more or less consolidated by the introduction of more manganese oxide from other parts of the deposit". The alteration of almost all the feldspars in the rocks of the series into Kaolin and lithomarge is attributed to the agency of water and CO_2 .

The type Khondalite is said to be composed essentially of garnet, silliminite, quartz and graphite and Dr. Fermor is of opinion that all the black spots and areas in the rocks of the series are not graphites but are manganese oxides, always deposited in the present form subsequent to the formation of the rocks.

The Khondalites are considered to be paraschists or metamorphosed sediments. Similarly also the calc gneisses closely associated with the Khondalites and usually occurring at the junction of the latter and the garnetiferous biotite gneiss. The last mentioned rocks that are largely in evidence near Chipurapalli are reckoned as later intrusives. Such in brief are the opinions held about the several rock-formations by previous observers.

In the short time at my disposal I paid hurried visits

* Trans. Min. & Geol. Institute of India, Vol. I, page 28.
Dr. Walker Mem. Geol. Surv. of India, Vol. XXXIII

to the Manganese Mines of Kodur, Garbham and Avagudem and examined the intervening country in the hope of finding evidences suggesting the above mentioned correlation of rocks. But the evidences obtained are so conflicting that I am inclined to offer a different interpretation to the rock occurrences, which however by no means should be taken as my final and well formed opinion in the matter. It should be regarded as mere suggestions for consideration.

In the area traversed I was not able to see any radical difference between the so-called Kodurites (quartz felspar rocks, felspar spandite rocks, &c.,) at the Manganese Mines of Kodur and Avagudem, and the Khondalites on the conical hill 2 miles S of Chipurapalli to the left of the road on way to the Kodur Mine and on the hill ridge to the East of Avagudem manganese excavations. Streaks of chert or opal, and stained lithomargic patches consequent on the alteration of the felspars characterise all. Quartz reefs having graphite scales have intruded both the Kodurites and the Khondalites; and spandite garnets (orange brown in sections) have been developed largely at contact. Nowhere did I see the members of the Kodurite series intrude the Khondalites.

A clear instance of the formation of calc gneiss (metamorphosed Khondalite of Dr. Walker) at the junction of the graphite carrying intrusive quartz vein (direction 20° N of E) and the felspar garnet rock (direction 20° N of W) can be seen at the road crossing of the former 2 miles S of Chipurapalli.

The highly contorted calc gneiss - D/207 - forming a dark bold ridge close to Garividi Ry. Station not far from the Kodurites of the Kodur Mine resemble the calc granulites of the Central Provinces. In a section of the rock I noticed orange coloured garnets besides other minerals and a curious intergrowth of quartz and calcite suggestive of quartz felspar pegmatitic alteration.

On the hill range to the North of Avagudem which has been regarded as a typical Khondalite area, the Khondalite rocks are generally composed of quartz and garnets and have sparingly developed, silliminite and that too at contact with either the pink garnet gneiss, or thin quartz reef carrying graphite. The garnets are rose red in colour like the ones in the garnetiferous biotite gneisses of the plains. The gneisses too are silliminitic - D/235 - for instance on the dark looking dome shaped hill $1\frac{1}{2}$ miles N.E. of Chipunapalli.

Considering all the facts observed, I am inclined to simplify matters by regarding the Kodurites and the Khondalites to be one and the same derived from the metamorphism of arenaceous, argillaceous and manganiferous sediments. I would suggest for consideration the following sequence of events which I think have probably occurred in the area in the order set forth :-

(1) That after the deposition of the sediments (the present Kodurites and Khondalites) the country was invaded by biotite gneiss which piecemealed the sediments;

(2) That this intrusive gneiss metamorphosed the sediments and also gave rise in places, to the formation of calc gneisses and silliminite bearing rocks (Khondalites) at contact. Owing to reaction the intruded body also became silliminitic;

(3) That the whole region was then subjected to dynamic metamorphism resulting in the more or less wholesale development of rose red garnets in all the rocks;

(4) The decomposition of the felspar and other minerals in the metamorphosed sediments was brought about by meteoric waters and this is especially noticeable in the non-garnetiferous portions (Kodurites). Finally such decomposition ended in the replacement of altered minerals by manganese oxide in

the manner detailed by Dr. Fermor on pages 262 to 272, Mem. G.S.I. Vol. XXXVII ;

(5) The later intrusion of the graphite bearing quartz reefs in such a manganiferous zone of metamorphic sediments gave rise to the development of garnets, principally spandites which through alteration as at Avagudem Mine have yielded the manganese ores. They have also given rise to ~~calc~~ granulites; and

(6) That these graphitic quartz reefs coming through the sillinite bearing portions of the metamorphosed sediments have contributed to the formation of garnet sillinite, quartz, graphite rocks (the typical Khondalites *of* Dr. Walker).

'Red Hills' laterite.

On my way to Bangalore I had to pass Madras and I took the opportunity to see the 'Red Hills' laterite. It was a great disappointment for none of the nullas and the artificial cuttings in the laterite were deep enough to expose either good sections or the underlying rocks.

After thus recounting my geological observations in the several provinces of Northern India, I shall now give brief reports of the Industrial concerns visited by me during the tour with such suggestions suitable ~~to~~ ^{for} adoption in Mysore.

The Perfect Pottery Works, Jubbulpore.

There are two important pottery works in Jubbulpore. That of Messrs. Burn & Co., an European Concern, is situated close to the Railway Station; The other "The Perfect Pottery Works" having an Indian Directorate is at Polipathar 3 miles away from it on the Seoni Road. First I approached the Manager of Messrs. Burn & Co. to kindly permit me to see the works but he flatly refused admission even though I mentioned to him that I was deputed by the Mysore Durbar to study such industrial concerns. Next, I visited the Perfect Pottery Works where I experienced no difficulty in gaining access. The business Manager, Mr. Reid, being unfortunately absent at the time, I was not able to obtain much information about the raw materials, their manipulation and other particulars connected with the industry.

Within the premises is a large clay pit in the horizontal bed of white Jubbulpore Clay which is 12 to 20 ft. thick, below the gritty sandstones of variable thickness. The clay is quarried in the usual way, crushed dry in a mortar mill and then passed on automatically to a winnowing machine in small cups attached to an endless revolving belt. The winnow separates the coarse and fine particles, sends back the former to another mortar mill for further crushing and the latter to a pug mill where it is mixed up with water and kneaded well. It is now ready for the several presses intended for the manufacture of clay articles.

Sewage Pipe Manufacture.

The kneaded clay is hand fed into a cylinder which has a solid circular rod of the size and shape of the pipe needed, moving freely up and down in it. Quite detached from the cylinder is a solid disc which on release of a clutch moves up and meets the descending rod from the cylinder. The united efforts

efforts of the two - the rod and the disc - result in the manufacture of a sewage pipe from the kneaded clay, the former imparting the shape of the hollow pipe and the latter the joint portion. The sewage pipe is then chopped off at the right place by a wire cutting arrangement and allowed to dry on an half cylindrical wooden press before it is transported to a large circular shaped kiln about 22 ft. diameter and about 10 ft. high for burning. The whole plant is worked by a steam engine for which coal is used. The kiln is lined inside with fire bricks and has down draft arrangement.

The sewage pipes, fire bricks or any other material intended for burning are let into it by a single doorway and the fuel is charged from the outside into 8 smaller vents in the chamber wall. The kiln, I was told, develops a temperature of 1400° to 1700°C . There are 10 such kilns in the works and each is capable of taking in 6000 fire bricks per charge.

I was given to understand that the Perfect Pottery Works prepare Tiles, Fire bricks, Sewage pipes, gully traps, garden rustic pipes, vases, acid jars, washing sinks with overflow arrangement and several other articles from the Jubbulpore Clay, which is well suited for their manufacture. There is apparently a large demand for the sewage pipes in N. India and I found the yard full of this ware.

The Glass Factory, Jubbulpore.

The Glass Factory, which is located not far from the Gun Carriage Factory, Jubbulpore, is a native concern unfortunately showing signs of mismanagement. If properly worked on scientific lines and manned by men with business habits ~~the~~ there is a bright future for the industry. At present every thing is left to the management of ^a Mohamedan gentleman who happens to be a skilled glass blower having had his training for several years at Amballa and other glass factories. No Chemists are employed to try experiments on the raw materials for the proper production of clean transparent Glass ware free from ~~cloudiness~~ cloudiness, spots, blowholes &c. The raw materials gathered together are thrown into the melting pot more or less in an haphazard manner and no wonder that the lamp chimneys and other articles produced are not very much patronized. The concern too is not properly advertised and the articles manufactured do not bear the impress 'Jubbulpore Glass Factory'

There are two large furnaces of the usual pattern in operation and a third newly built one though complete was not put to any use. It appears the proprietors are contemplating to reserve that entirely for the manufacture of Soda Water bottles.

Evidently there were some orders from the Railway authorities in India for I noticed different shapes and sizes of lamp chimneys and glass shades used in Railways being blown from the molten glass, annealed in a furnace like that of a baker's oven, and trimmed to shape. Ordinary glass chimneys for lamps were also being manufactured largely. Nearly 200 persons are employed in the works, half of whom are women, and I was informed that the output of glass articles per day was worth about Rs.200/-.

The raw materials needed for glass manufacture are either got out locally or purchased from abroad. The sand needed is obtained from the bed of the Jubbulpore formation occurring in the factory premises. The soda is got from Calcutta at Rs.7/- per cwt. Saltpetre and arsenic are also purchased.

The process of glass manufacture adopted appears to be simple. The raw materials are mixed up in certain proportions and fused in the glass furnace. The molten glass is taken out by hollow iron rods, then after being blown a little by the mouth, it is immersed and rolled in a mixture of castor oil and water to ensure rapid rolling and flow. After a little more blowing, which imparts a sort of oval or globular expansion, the glass bulb is thrust into any pattern mould (chimneys, shades &c.) and blown hard by skilled men through the hollow rod to give the glass the shape of the mould. The glass ware thus produced is heated in an annealing furnace for some time, then taken out and turned to proper shape by means of circular sharp edged pinkish sandstone discs revolving on a shaft moved by an oil engine. The men at the discs chop off the top and bottom portions and the finishing touches of smoothening are done by women who merely hold the cut edges over an horizontally revolving disc of sandstone on which there is a constant trickle of fine sand and water. The glass articles thus prepared are now ready for the market and as mentioned already they are not free from cloudiness and blow holes.

A unique feature in this glass factory is the training given to some 40 students in glass making- blowing methods &c. I was given to understand that the students are even paid Rs.10 to 12 per month to induce them to learn the Art.

Cement Works, Katni.

It has been truly said "that the two great discoveries of the nineteenth century were Bessemer Steel and Portland cement". "Many of the greatest engineering feats of modern times could never have been carried out without the use of the artificial cement, or of the concrete which is made from it". On account of its wide application the production of cement, as an industrial concern, has attracted the attention of capitalists and of Government. The raw materials necessary for its manufacture being simple limestone or chalk and clay or shale - and of fairly wide occurrence in nature, it is considered an easy proposition to start cement works in every place just like so many brick kilns. But it is not so, Any and every calcareous and argillaceous material will not yield by mere calcination the silicates and aluminates of lime which form its chief components. A considerable amount of chemical technique is involved, and one has to be extra careful in selecting the right proportions of the raw materials for the production of cement having constant chemical composition. "A portland cement mixture when ready for burning should contain about 20% Silica(SiO_2), Alumina Al_2O_3 and iron oxide (Fe_2O_3) together, the remaining 5% containing only magnesia, sulphur and alkalis that may be present."

The commercial success of the industry depends very largely on the efficiency and thoroughness of the grinding of the raw materials and of the clinker produced by their calcination in properly arranged kilns. For the production of a ton of cement about 32 cwts of raw materials (75% of which is hard limestone) have to be crushed to an impalpable condition.

* W.A. Brown. The Portland Cement Industry. p.9.

thoroughly mixed and calcined at a temperature of 2800°F and the resultant Clinker cooled and ground so fine that about 82 to 90% or more of the finished product (cement) will have to pass through a sieve with 32400 holes per square inch. This is not all. In order to satisfy specifications mechanical tests determining the time of "setting", strength and behaviour of the cement, tensile, pressure, resistance and expansion tests will have to be made in the Laboratory before it is sent out. Thus it is evident that a considerable amount of technique and skill are involved before a satisfactory cement is produced.

While at Katni I felt very anxious, therefore, to see the up-to-date cement plant that produced the famous 'Katni' brand. Access to the works is by no means easy. Outsiders are not permitted to enter and it is rarely or never that a visitor is allowed to get into the premises. Through the co-operation of Mr. George Forester of Katni and through the kindness of the business Manager ~~that~~ I was able to see the extensive works and the interesting laboratory arrangements for conducting chemical and physical tests. There are 4 large steam boilers which drive the dynamos. They generate ~~and~~ ^{the} electric power necessary to propel the crushing, etc., machineries. The limestone found so largely at Katni, is broken into small pieces by 'Blake type crushers' then passed on for being ground down to powder to the Ball Mill having steel balls. Further, fine grinding is brought about in a Tube Mill having hard round stones (flints got from abroad were formerly used but now round quartz pebbles from the river close by are used) which in falling one upon the other pounded and crushed the limestone to a fine flour-like powder. This is passed on through belts to a mixing drum wherein the finely powdered clay obtained from the neighbourhood is also let in. If attention is not paid to the mixing of the raw materials in the correct proportions at

the commencement, no amount of care in the later stages will put matters right. So the Chemist~~/~~ determines~~/~~ now the proportions before the mixing is effected. In the drum a thorough mixing of the raw materials with water takes place and the semi liquid 'slurry' is conducted to ~~/~~ large vats where further mixing is brought about by the movement of the horizontal arms fixed like spokes in a wheel to revolving shafts. This stirring also prevents the 'setting'. The churned liquid overflow undergoes another such stirring in vats before it is finally led on to one end of a long slightly inclined and slowly revolving iron tube 'the rotary kiln' where coming in contact with the flames generated by the burning of coke, the liquid slurry is uniformly and regularly calcined forming clinker. The temperature of the kiln is merely judged by the 'eye'. The Manager told me that it ~~wasre~~ something like 1400°C.

The clinker which is dark gray or black is then allowed to drop into a cooling chamber also cylindrical. It is then removed on trucks running on rails to the stacking yard where it is left to cool for a week or ~~more~~ before subjecting it to crushing in a ball mill and a tube mill similar to those used for crushing limestones. Along with the clinker before crushing few pieces of gypsum are added evidently with the object of making it set slowly. While the finely crushed cement is being led on by belts to the storage godowns, automatic samples are being taken for conducting physical tests in the laboratory by an ingenious contrivance which consists of a number of small tin cups attached to an ever revolving belt placed at right angles to the large cement conveying belt. Each tin cup in its upward motion carries a portion of the cement from the revolving conveying belt and tips it on to a bucket close by in its downward path thus making up automatically samples for bricquettes to test setting, crush resistance &c.

In the laboratory the cement is screened through a fine mesh of fixed standard and it is passed if the coarser particles that do not pass the screen are less than 14% by weight. There is also self registering crushing machine. The hard set briquette of cement is taken out of the water clasped between two claws of the crush machine. The pendulum of the horizontal beam being set in motion, it travels slowly from one end to the other thereby exerting a pressure on the briquette until the latter snaps. Immediately the pendulum comes to ~~the~~ rest and the figures indicates crushing strength. There are also arrangements for testing the 'setting' time, chemical purity, &c. of the cement.

The cement, when passed by such testings, are stitched in bags and put on rails. I was informed that the Company authorities were contemplating to introduce machinery to weigh certain quantity of cement, to put them in bags, and to stitch them all to be done automatically. If this is accomplished, there will then be very little labour seen inside the cement works.

Duplicate sets of crushing and grinding machinery and mixing plant have been installed to meet emergencies and to allow the overhauling and cleaning of one set while the other is in operation.

As a subsidiary occupation a few fire bricks and tiles are being manufactured in the premises.

From the foregoing description it can be made out that the starting of a cement industry in a place involves considerable ~~site~~ preliminary investigation. First of all, a suitable site for the location and erection of the plant should be chosen with reference to the deposits of the raw materials, rail and water communication and the available markets for the produce.

The abundance of raw materials - Lower Vindhyan limestone and clays - suitable for cement occurring in the neighbourhood and the branching out of several Railways to take the product away mark out Katni as an ideal locality for cement manufacture. Secondly, the services of skilled engineers and Chemists - "men who have gained their knowledge after years of practical experience in cement making, and not those who have visited a few cement works in Europe & America gleaning information from owners and Managers" - should be requisitioned to erect buildings, to equip the plant and to conduct operations. The quantity of cement produced is also of great importance in determining the cost of manufacture. It is only by paying attention to such factors that the success of the undertaking can be ensured.

Olpherts Paint Works, Katni.

The paint works of the 'Olpherts Paints and Products Ltd. managed by Messrs. Grandage Moir & Co. of Calcutta are located on the banks of the Katni river close to the town of Katni. The offices, Engine rooms, drying yards, Officers quarters &c. are being constructed on the right bank of the river. The extensive site on the left bank is intended for the housing of the workmen and the menial staff. It is the intention of the business manager, Mr. George Forrester, to create here a nicely designed garden suburb, by assigning to each workman a plot of ground and inducing him to plant useful fruit trees.

The concern being still in its infancy there is very little work actually being done. The Haematitic and limonitic Schists and ochres that are got out of Jaoli and other places in the Jubbulpore District are being pulverized dry on the right bank of the river in the ordinary edge runners (a kind of mortar roller consisting of heavy round stone discs running in circular grooves or channels and fixed to long wooden poles that are moved round by pairs of bullocks). The powdered materials are sieved. The coarse particles that do not pass the sieves are again ground in the edge runners. The fines are sent to the vats, mixed with water baled out from the river, and passed on to the 'grinders' which are located in the bed of the stream on a dam (specially constructed right across) which has several arched openings below for the passage of water in normal times. Moveable shutters are provided for the openings to regulate the water flow in them. In the passages are spindles, which are moved by the flow of water thus regulated, and they in their turn move each 2 circular stone discs (grinders) that are attached to every one of them. There are 16 such grinders. The 'slurry' like paint powder are ground finer and finer in a set of eight such revolving stone discs. At every disc a woman is seated and

it is her duty to feed with long ladles the paint powder to the disc for grinding. After the powder passes the last disc of the set it is ~~carried~~ led on by the help of water to a series of 3 large settling tanks or vats. The finest powder from the last one is removed for drying to vats specially constructed with cemented sandstone flags at the bottom, on the right bank of the river. The vats are each 2 to 3 ft. deep. After complete drying the paint powders are bagged and sent outside as such or are mixed with oils.

Just now the Company is manufacturing only 4 colours of paints - yellow, Tan, Red and dark red from the soft haematitic and limonitic schists & ochres. The oil paints prepared by ~~the~~ Company are superior to our local productions. The latter appear dull and lack opacity. The condition of the paints produced in the Mysore State can be improved if more attention is paid to the grinding which is now being done in a crude unsatisfactory way in edge runners and by hand grinding method. Compared with the raw materials obtained in Jubbulpore, the coloured ochres of Mysore are fairly gritty and hard, and it is therefore of paramount importance that fine grinding should be resorted to in order to make the paints got out, more attractive than at present.

It is the intention of the Olpherts Paints & Products Ltd. at Kathi to start the manufacture at an early date of metallic paints oils, Varnishes and Shellac. In a paint works these are necessary adjuncts, especially the oils, and it is therefore a matter which deserves the serious consideration of the Mysore public interested in the successful manufacture of paints to prepare their own Linseed, turpentine and other oils.

Calcutta.

During my short stay of 10 days at Calcutta I saw quite a number of institutions and business concerns chief among them being the Presidency College, Calcutta, the University College of Science and Sibpur Engineering College, the Geological and Topographical Survey Offices, Mr. Deb's Pottery Works, Mr. Dutt's Machine and Tool Works and the Museum. At the last mentioned place I spent all available hours especially in the geological and economic products sections day after day in studying the unique collection of rocks, minerals, fossils and other interesting exhibits. I have taken some useful notes of the methods of arrangement adopted and of the manner of presentation of the several exhibits. There is so much to learn here that I always wished I had more time at my disposal. Since it is highly desirable that our Museums in the Mysore Province should also be equipped and arranged in a similar manner, I would suggest the sending in ~~on~~ on deputation of a qualified skilled draftsman to visit the Calcutta and Bombay Museums for about a month or so to make notes and drawings of the different modes of presentation of the exhibits. It becomes also imperative that liberal grants should be provided for to make the Museums look attractive.

From the visits to the educational institutions I was able to get a fair idea of the nature of the work that is turned out, their equipment and other details. By coming in contact with such eminent scientists like Mr. C.V. Raman and by seeing them work in their laboratories I derived much benefit.

The Pottery Works of Mr. Deb and the articles turned out by him at the place have formed the subject matter of good many reports submitted to Government by persons who have been to Calcutta before and hence I shall refrain from entering into descriptions. I watched the different processes of figure modelling and moulding, of the manufacture of porcelain insulators, cleats &c. with interest. The glazing is done by dipping the porcelain ware before firing into a mixture of and then burning them. This imparts the requiring glaze. Considering the way things are being done in this Pottery Work from raw materials almost all obtained from abroad, it is high time that Mysore which has kaolin, felspar and quartz in her territories rises up to the occasion and produces porcelain crucibles, insulators and other classes of China Ware at no distant date. Mr. Deb informed me that he had sent in proposals for the start of a porcelain factory in Mysore after testing the Mysore Kaolins, felspars &c., and that he had received no further communications on the subject. He is clever and really sincere in his endeavours to start concerns for the good of India. Since he is posted well with the business technique of porcelain manufacture I would humbly suggest to Government to engage his services at an early date and to start the industry which is likely to prove a success, if well engineered.

Bye-product Coke oven plant - Lodna Colliery.

When I expressed a desire to Mr. H.H. Hayden, Director of the Geological Survey of India, to see an up-to-date Bye-product coke oven, he kindly arranged with Mr. Argyle and obtained his permission for me to visit the plant at the Lodna Colliery, ~~Gherria~~. Here coke is produced from the burning of powdered slack coal in a battery of 30 long narrow longitudinal chambers with vertical flues between in which a portion of the gas generated is burnt to heat the ovens. From the gas which is led on through regulated valves and through a large pipe to a cooler, the bye-product coal tar is condensed to atmospheric temperature and is collected in underground tanks. Since the direct method of the manufacture of Ammonium Sulphate by allowing the gas to come in contact with the sulphuric acid direct is adopted at Lodna, special precautions are taken to remove first, all the finer particles of tar from the gas by passing it through a gyratory drum and again further passing it through a Simons Carves drum which has blades rotating inside. As soon as the gas is tar free, it is led on to an exhaustor connected to a Brown Boveri steam turbine, whereupon under compression it is admitted into a lead lined sulphuric acid retort. The ammonia in the gas combines with H_2SO_4 and forms Ammonium Sulphate. It is then drawn out to a flat tub with holes at the bottom for the removal of the sulphate of ammonia which is then collected and bagged. At the time of my visit, Ammonium Sulphate was not being manufactured as there was no sulphuric acid. Hence the gas after parting with its tar was partly sent back to the flues between the coke ovens and partly made use of in working a dynamo. In this manner only 25% of the gas produced from the coke ovens was used up, while the 75% was burnt uselessly in the air at the end of long tube. It is intended to make use of the gas, now allowed to be burnt up unprofitably, in generating electricity which will simplify haulage, lighting, &c., in the adjoining collieries.

While at the coke ovens I had the rare opportunity to witness the discharge of the burnt coke from one of the ovens. The coal which was burning inside for 33 hours at a temperature of 700° to 950° C was pushed out by an electrically driven ram on to a sloping siding where it was quenched with water.

Good coal from the Lodna Colliery is not made use of in the manufacture of coke. It is the 'slack' coal (fine powder, &c.,) that is concentrated into one phase being brought from several directions in tipping waggons on rails. The 'slack' coal is dumped on to a grating screen through which it gets into a low chamber below, whereupon it is automatically fed into a disintegrator and crusher. By means of a bucket elevator the crushed coal passes into a large overhead bunker (60 ft. high from the ground) capable of holding 300 tons of coal. From the 3 adjustable orifices at the bottom of the bunker this powdered coal is fed into tubs which moving on rails along the roof of the battery of coke ovens charge the narrow longitudinal chambers below through a set of three changing holes each. The coal is then set fire to in the ovens resulting in the formation of coke. I was not successful in getting any information as to production, costs, &c.

An excellent description with diagrams and statistics of the Bye-product coke ovens in use at the Giridh Colliery is given in the recent Transactions of the Mining and Geological Institute of India, Vol. XIV, Pt.2, by Mr.G.W. Marshall.

In many respects the Giridh resembles the Lodna plant except for the manufacture of Ammonia Sulphate which is produced there by the old 'Indirect Recovery' method.

In the event of coke being indented for largely from abroad to serve as fuel for any of the Industries started by the Mysore Government, such as Iron Smelting, Sandalwood oil

distillation, etc., it is then worth while considering whether coal cannot be imported instead of coke and a bye product coke oven plant installed to obtain coal tar and its derivatives (creosote, &c.,) and the Sulphate of Ammonia which is a very good fertilizer.

In conclusion I beg to express once more my thanks to the Mysore Government for having given me an opportunity to obtain first hand information of several rock formations, mineral deposits and industrial concerns in Northern India. My only regret is the time was not enough to study more of them in detail.

(Signed) P. Sampat Singh

Bangalore,

(Deputy Director of Geology).

30th June 1920.

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Bangalore }
24th Aug 1920 }

B. Laya Ram
Director
Mysore Geological Dept